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Fig. 1.—View of lower stern, showing setting of rudder, propeller, etc.

AUDEL'S SHIP FITTERS' GUIDE

A PRACTICAL TREATISE
ON
STEEL SHIP BUILDING
AND
REPAIRING
WITH INSTRUCTION IN
MOLD LOFT WORK
LIFTING, DUPLICATING
INCLUDING
TEMPLATE MAKING - PLAN READING - PARTS OF A STEEL SHIP - TERMS AND DEFINITIONS - DEVELOPING PLATES AND BARS - SHEARING - BEVELING - SCARPHING - INSERTING LINERS - RIVETING AND RIVET TABLES
WITH
ILLUSTRATIONS SHOWING CURRENT PRACTICE

BY
RALPH NEWSTEAD

THEO. AUDEL & Co PUBLISHERS

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PREFACE

Shipfitting is one of the important branches of the shipbuilding industry and requires one to have a certain amount of technical knowledge and practical experience to overcome the difficulties which generally confront the average worker.

The author in preparation of the work has had two objects constantly in view: first to familiarize the reader with the leading operations of shipfitting; and secondly, to furnish him with as much advice, instruction and information, as possible within the limits of this work.

This Guide will be useful to all men engaged in the shipbuilding industry. It is is not a book of theories—it is a practical treatise, the aim being to present the subject in as simple a form as possible so any ship worker can understand it.

With this in view, the author, who has had twenty-five years experience in shipfitting, has been careful to omit all unnecessary details, and to present only such information as will be needed to prepare the reader for all emergencies.

The author and publishers are indebted to the "Chester Compass" of the Chester Shipbuilding Co., for excellent material on Shipfitting, the Mold Loft and Drafting.

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"BUILD ME STRAIGHT, O WORTHY MASTER
STANCH AND STRONG, A GOODLY VESSEL,
THAT SHALL LAUGH AT ALL DISASTER
AND WITH WAVE AND WHIRLWIND WRESTLE."

—*Longfellow.*

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PARTS OF A STEEL SHIP

Type Described: Three Deck Cargo Ship

Shell—The principal function of the shell is to act as a water-tight skin. It also gives strength to the construction of intermediate parts.

Transverses—These are the *ribs* or *frames* of the ship, and when placed in position, give the principal shape or contour. Transverses are not all the same distance apart; amidships, where there is the greatest strain, they are spaced more closely.

The transverses are cut or notched where they connect on the shell, to allow the longitudinals to pass through. They are strengthened by clips at these points.

Longitudinals—These run fore and aft from bulkhead to bulkhead, except in the shelter and upper decks, where some are broken by hatch interference.

Longitudinals give strength and rigidity to the frame work and shell. They are connected and riveted through the flange of the channel to the shell or deck.

Bulkheads—The vertical partitions that divide the hull into separate compartments are called bulkheads. Some are water-tight. These water-tight bulkheads are so arranged that in case of accident at sea, water would be confined to one compartment only.

The collision bulkhead in the front end is constructed to withstand heavy strain and shock in case the bow be staved in.

The number of bulkheads for a ship, according to Lloyd's are as follows:

A ship between 220 and 285 feet long, 4 bulkheads.
A ship between 285 and 335 feet long, 5 bulkheads.
A ship between 335 and 405 feet long, 6 bulkheads.
A ship between 405 and 470 feet long, 7 bulkheads.
A ship between 470 and 540 feet long, 8 bulkheads.
A ship between 540 and 610 feet long, 9 bulkheads.
A ship between 610 and 680 feet long, 10 bulkheads.

Names of all plates, straps, etc., in the hull.

Flat keel.
Vertical keel.
Keel butt strap.
Floors.
Partial floors.
Fore peak floors.
After peak floors.
Fore peak intercostals.
After peak intercostals.
Side girders.
Brackets.
Spare.
Bilge.
Bilge keel.
Longitudinal brackets.
Turbine seating.
Margin plates.
Shaft tunnel sides.
Shaft tunnel top.
Settling tank.
Diaphragm plates.
Deep tank top.
Deep tank web.
Deep tank brackets.
Shaft tunnel stools.
Shaft thrust recess.
Shaft thrust recess top.
Shaft thrust recess B H.
Bulkhead plating.
Chain locker sides.
Chain locker middle.
Chain locker front.
Panting stringer.
Fore peak web.
Fore peak W T flat.
Fore peak swash.
After peak swash.
W-tight flat.
Swash flat.
Transom.
Cant brackets to transom.
Breast hooks.
Bulkhead webs.
Center line bulkhead.
Bulkhead brackets.
Dynamo flat.
Transverses.
Transverse bottom bracket.
Transverse middle bracket.
Transverse face plates.
Transverse top brackets.
Transverse top brackets deep tank.
Transverse upper deck.
Transverse deep tank.
Transverse upper deck face bar.
Face bar.
Hold pillar face plates.
Pillar base.
Upper deck hatch side girders.
Upper deck hatch face plate sides.

Decks.—The various decks are as follows:

First or upper deck.
Second or shelter deck.

The above decks run the full length of the ship.

Tank top which is below the upper deck.
Boat deck, situated amidships above the shelter deck.
Observation deck or captain's bridge, situated above the boat deck.
Poop deck in the aft or stern of boat.
Forecastle deck, for'ard or bow of ship.

Double bottom.—The double bottom extends from the flat keel to the tank top. It is strongly constructed and is water tight so that in case of accident causing an inrush of water into the double bottom, the ship would still be able to keep afloat.

Hatches.—There are four kinds of hatches:

1. Cargo.
2. Engine.
3. Boiler.
4. Deep tank.

They extend from the shelter deck down to the tank top. On this type of ship there are four cargo hatches; one engine hatch; one boiler hatch and one deep tank hatch.

Starting from the after end, the two first are cargo hatches, then engine, boiler, deep tank hatch and the last two are cargo hatches.

The hatches are situated at the middle of the ship, the center line of the ship extending through the middle of the hatches.

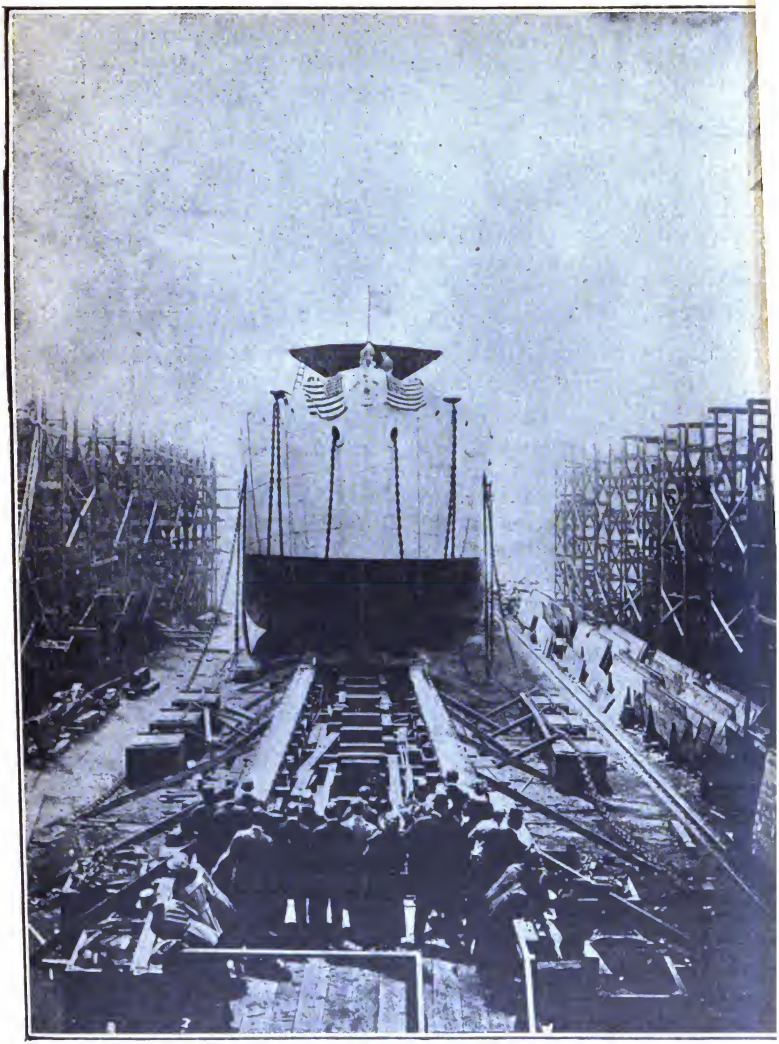


Fig. 3.—THE LAUNCHING. Note the drag anchor attached to chains to slacken the speed of the vessel.

The hatches on this type of ship cut through longitudinals 1, 2 and 3 on both sides of the center line. Longitudinals 4, 5, 6 and 7 not being interrupted, run through without break to the bulkheads.

The principal parts of the double bottom are the flat keel, vertical keel, floors, intercostal girders, bilge, brackets, tank top, longitudinals, bounding bars and angle clips.

From the tank top to the upper deck the principal parts are: bulkheads, pillars, deep tanks, bulk head stiffeners, girders, brackets, bounding angles, bar clips, shaft tunnel, engine seatings, longitudinals, man-holes and covers.

Plates, Straps, etc.—*Continued.*

Upper deck hatch face plate corners.
Upper deck hatch brackets.
Upper deck hatch pillar brackets.
Upper deck hatch beam webs.
Shelter deck hatch side girders.
Shelter deck hatch face plate sides.
Shelter deck hatch corners.
Shelter deck hatch brackets.
Shelter deck hatch pillar brackets.
Shelter deck hatch deep tank sides.
Shelter deck hatch beam webs.
Upper deck plates.
Gusset plate between deck.
Fr poop deck.
Fr poop top bracket.
T R Fo'csle web.
T R Fo'csle top bracket.
T R Fo'csle deck plate.
Poop deck plates.
Fo'csle deck doubling.
Boat deck tie plates.
Coal chute plates.
Casing top.
Stores upper deck plates.
Masts.
Masts doubling.
Gunwale bars (pronounced gunnel).
King post.
King post doubling.
Cargo boom.
Rudder.
Shelter deck house sides.
Shelter deck house ends.
Galley sides.
Galley ends.
Coaming.
Poop front.
Deep tank top plate.
Tank top plates.
Bounding bars.
Margin bars.
Stringer bars.
Channel bars.
Angle bars.

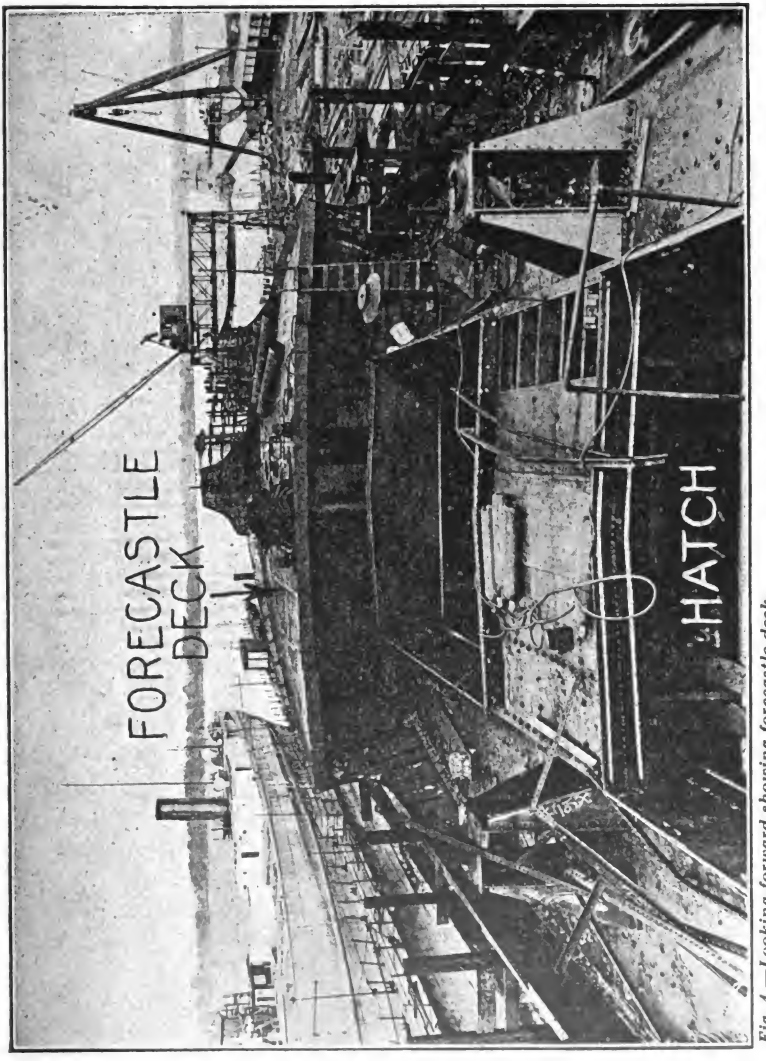


Fig. 4.—Looking forward showing forecastle deck.

MARINE AND SHIPBUILDING TERMS

After Body.—That part from midship to the stern.

Amidship.—The middle part or section of boat or vessel.

A. B.—An able-bodied seaman.

Angle Bar.—A bar, "L" shaped or two flanges at 90 degrees.

Angle Collar.—Circular angular section fastened around a column to hold the column to the deck.

Athwart Ship.—At right angles to the keel.

Awash—Level with the surface of the water.

Beam Angle Bar.—Used for beam construction, usually spanning the hull of a ship.

Bracket.—An iron or steel plate, fitted upright: for instance, in fastening a longitudinal to a bulkhead, etc.

Bells.—The audible indication of time at sea.

The clock bell is rung every half hour. Eight bells are rung 12—4—8. Therefore, one bell would be 12.30, 4:30 or 8:30. The bells are rung in rapid succession with a slight pause after the even numbers, usually a change of shift at 8 bells. After the bell is sounded at night, the look-out in the crows nest up on the main mast, calls out: "All's well."

Bevel.—To bevel a bar, the flange bent to a certain degree.

Bilge.—The round part of a vessel's bottom, or the curved part where it meets the sides.

Bilge Keel.—Angles or Tee bars, riveted at the lower turn of the bilge on the outside shell, to prevent excessive rolling at sea.

Boiler Room.—That part of ship where the boilers are placed, connected with boiler hatch to top deck.

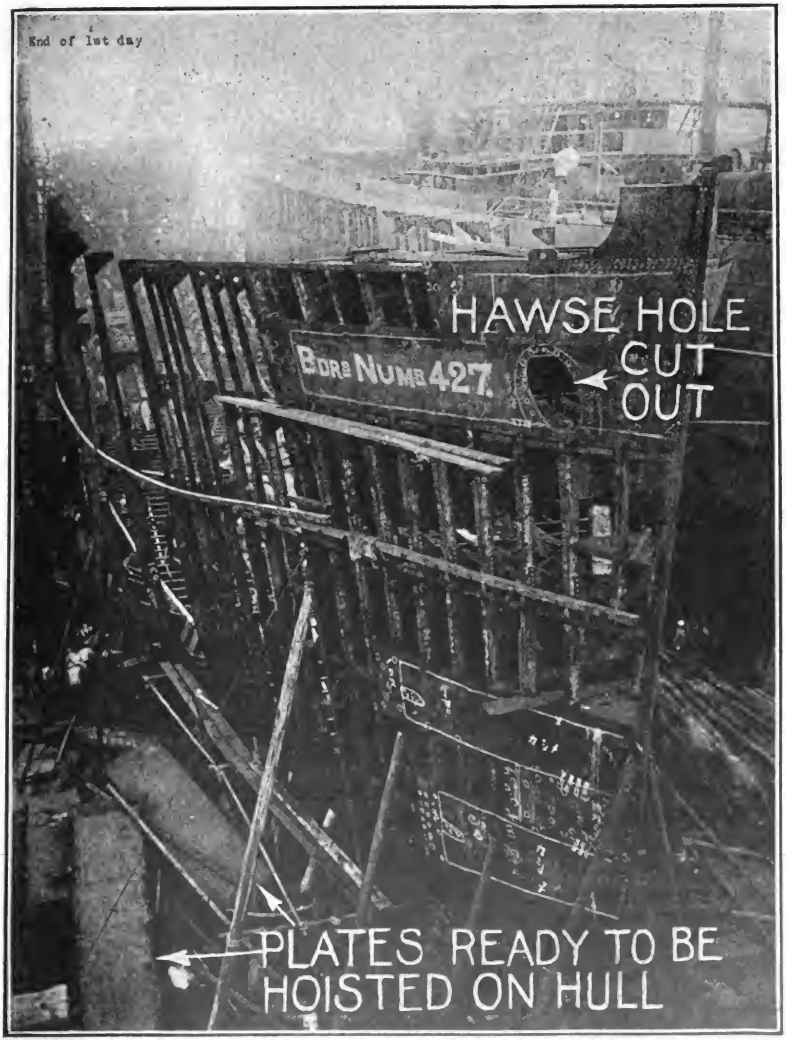


Fig. 5.—Forward section of hull showing frames or transverses in position.

Bosom Bar.—A short angular piece of bar of sufficient length, to connect the ends of two angle bars, usually three rivet holes on each side. The bosom bar, fitting in the bosom or inside of the angles.

Bosom.—The inside of a bar.

Boss Plate.—A plate at the after end, curved to make room for the boss of the propeller. This plate is of extra thickness and is always "lifted" from the ship.

Bow.—The front or fore end of a ship.

Breadth, Extreme.—The width of a ship, including the thickness of plates.

Breadth Molded.—Measured amidships at its greatest breadth to outside of frames.

Breadth Registered.—Measured amidships at its greatest breadth to outside plating.

Breast Beam.—The beam in the poop and forecastle decks, the beams nearest the amidships from these decks.

Bridge.—An elevated structure, extending from port to starboard, used by officers' pilots.

Buckled Plate.—A plate warped in or out at the center; a plate thicker at the center than at the edges.

Bulkhead.—A water tight partition extending from side to side and from the double bottom to the top main deck, so constructed that in case of accident in one compartment, damage is confined to that compartment.

Bulkheads impart strength and rigidity to the hull. They are stiffened by bars running port and starboard and in certain parts vertically. Various kinds of arrangements are used for passing through bulkheads, but the water-tight door is the most generally used.

Bulwark.—An extended plate around the upper decks.

Bunker.—A compartment in which fuel is stored.

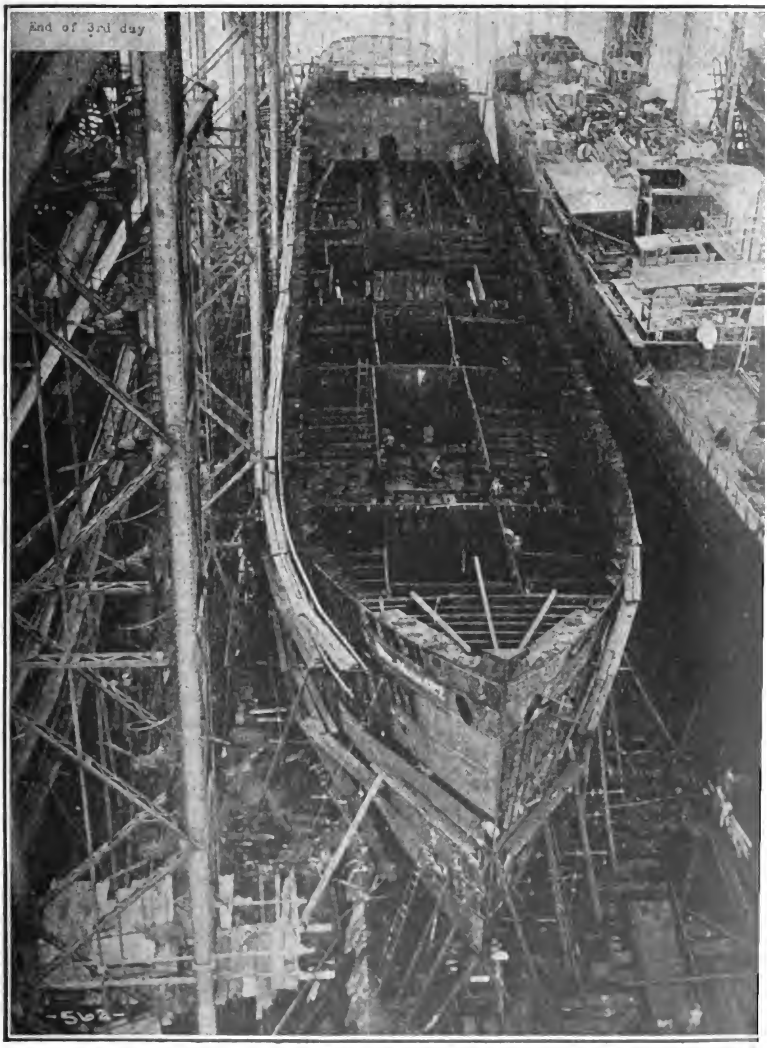


Fig. 6.—Looking aft, showing arrangement of bulkheads; note the shaft tunnel (aft

Burr Side.—When plates are punched for holes, the lower edge of hole will be rough, on circular work, as masts, posts, etc., the burr side is usually inside.

Butt Joint.—A joint formed by "butting" the edges of plates together and covering the seam with a butt strap.

Butt Strap.—A plate to connect two plates or bars together at the ends.

Buttock.—That part of the lower stern to the side of ship.

Camber.—The rise of a floor or deck.

Caulking.—The process of forcing in the edge where two plates overlap, by means of a caulking tool, to form a tight joint.

In wooden vessels the seams between the planks are caulked or made tight by forcing in *oakum* with a caulking tool and beatle.

Chain Locker.—The compartment, near and below the hawse holes at the bow, to stow the anchor chains.

Chain Pipe.—An iron pipe of large diameter, through which the chains pass into the chain locker.

Chalk Line.—A small line, strong enough to withstand being drawn very taut over a surface. The line is first chalked, then drawn taut between two points and "snapped," thus leaving an impression of the chalk on the surface to be marked.

The chalk comes in round pieces to fit the palm of the hand.

Clips.—A short angle bar connecting plates and shapes, also small spring clamps used to hold a template securely in place while the holes in the template are being duplicated.

These are made of iron or steel, in the shape of a horseshoe, but the prongs come closer together.

Coaming.—Raised plates or planking around hatches, skylights, mounts, etc.

Collision Bulkhead.—The bulkhead at the fore peak, extending to main deck.

Companion Way.—The passage leading from the deck to the messroom, etc.

Countersunk Hole.—A hole punched and bored conical shape for rivets to be countersunk or made flush with the plate; used for water tight work and for an even surface such as deck floors.

Countersunk Rivet.—A rivet not extending out from the plate or bar, hammered flush or even with surface.

Dead Flat.—The parts amidships forward and aft from the center of the ship, that are the same in measurement.

Deck.—An approximately horizontal platform or floor extending from side to side of a ship or of part of a ship, as of a deck house, and supported by beams and carlines.

Deck House.—A small house erected upon the deck of a ship for any purpose.

Depth, Molded.—Measured amidships from the top of keel to the top of beam at the upper deck.

Derelict.—A vessel abandoned at sea.

Displacement.—Total weight of ship while afloat, including everything aboard.

Donkey Engine.—An auxiliary engine to operate the lifting apparatus on deck.

Double Bottom.—A cellular structure consisting of water-tight compartments, and, therefore, used as water ballast tanks, when necessary.

Doubling.—An extra plate, for additional strength.

Draught Marks.—The stern and stem are marked in feet to show the draught or depth of the vessel.

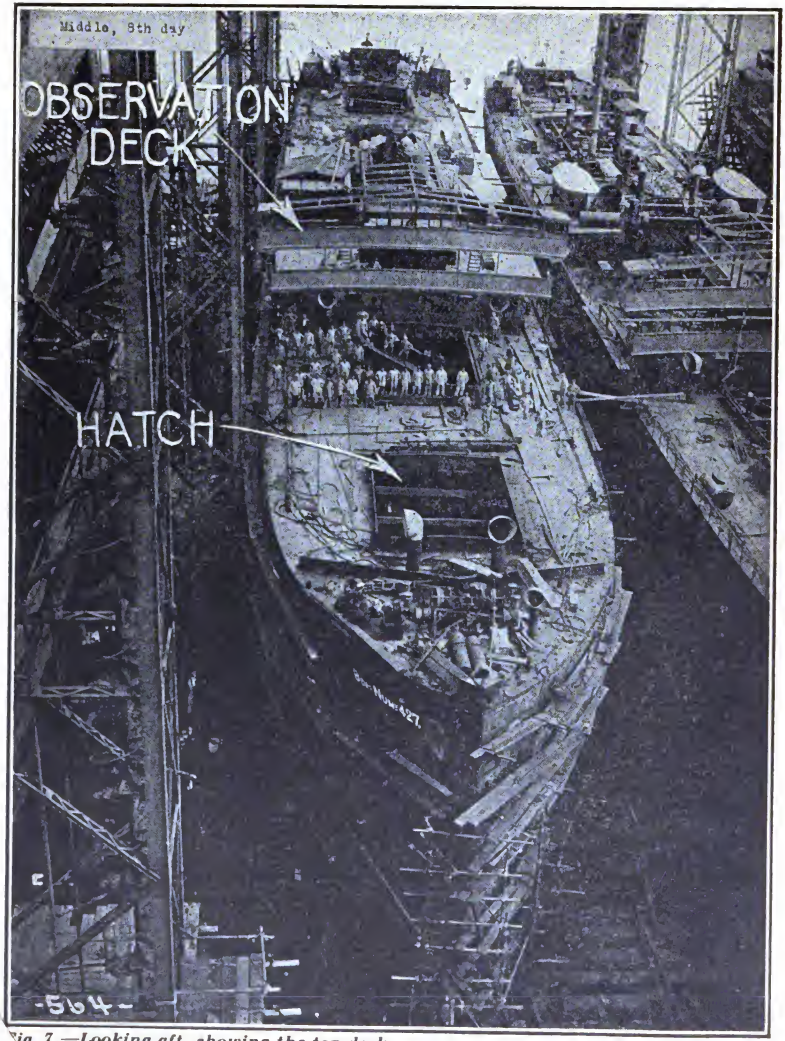


Fig. 7.—Looking aft, showing the top deck.

Duplicating Pipe.—A piece of tubing, generally brass, used with paint to transfer rivet hole layout from template to plate.

The end of the pipe is dipped in paint, and while still wet is pushed through each hole, leaving an impression on the plate.

Ductility.—Ability of a metal to be "worked" without cracking.

Engine Room.—Where the engines of a ship are confined, next to the boilers.

Expansion Tanks.—Compartments in tankers, fitted between the decks to allow the transfer of oil, on account of expansion due to high temperature, etc.

Fair.—Even, smooth. Fairing lines consist in making them even. Rivet holes are fair when they coincide in adjoining parts.

Fantail.—The upper and round part of the stern. The frames or cants are arranged like the tail of the famous breed of pigeons, the fantail.

Fathom.—Six feet; a marine unit for measuring depth.

Fillet.—The small rounded corners of rolled steel parts such as channels and angles.

Floors.—A series of vertical plates, connected, running port and starboard in the double bottom.

Flotsam.—The parts from a wrecked ship.

Forebody.—That part from the amidships to the front of stem.

Forecastle.—A superstructure upon the main deck at the fore end.

Freeboard.—The distance from water line to top of bulwark, amidships.

Garboard.—The plating next to the flat keel, or what is known as strake A.

Girder.—A massive beam or bar, a series of plates fitted to support and bind extra heavy weights.

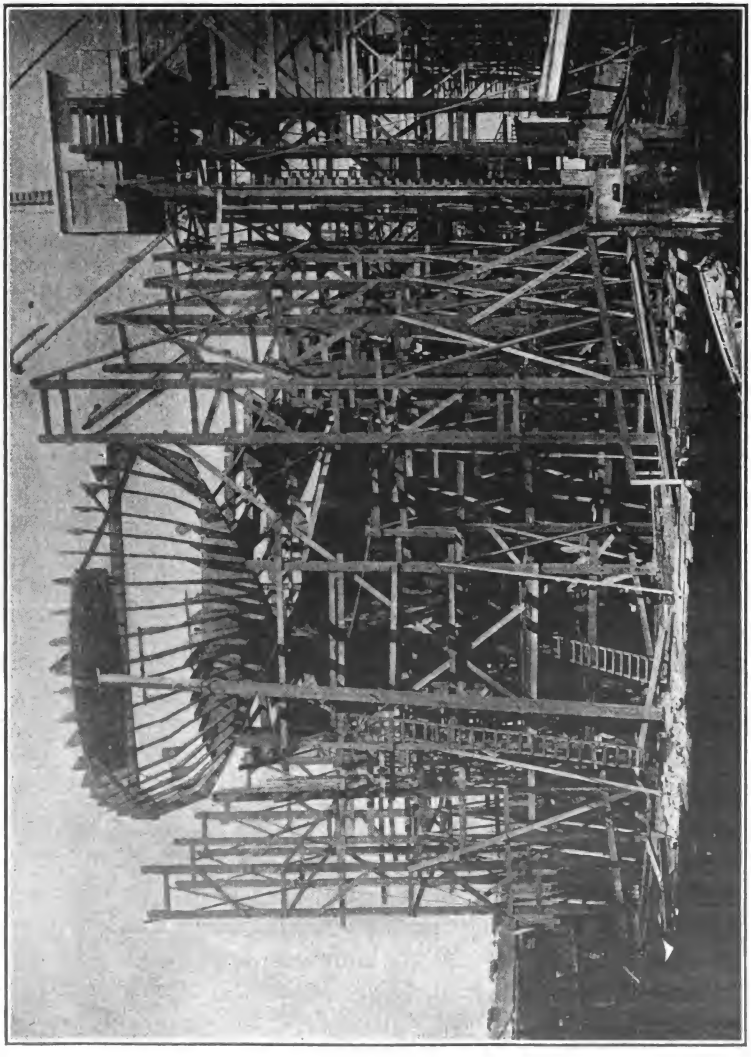


Fig. 8.—Fantail in position on the hull.

Gross tonnage.—The whole available space in every part of the ship that is in use for cargo.

Gunwale.—The side of a vessel at the edge of the weather deck.

Gunwale Bar.—An angle on the deck connecting both deck and shed. Pronounced gunnel.

Gusset Plate.—An angular plate serving the same purpose as a bracket plate.

Hatch Battens.—Thin strips of wood fitted tight against the coamings to hold the hatch covering or tarpaulin, in place.

Hawse Pipe.—A cast iron pipe connected to the hawse hole for chains or cables to pass through.

Hawse Plug.—A wooden plug used to plug up the hawse hole in stormy weather.

Heel.—The intersecting point or corner of the web and flange of a bar.

Helm.—The rudder, steering wheel and tiller.

Hold.—The space reserved for cargo.

Hull.—The body of a ship, including decks, bulkheads, shell-plating, etc.

Hull Down.—A ship at sea, on the horizon, the hull below the line, and only the masts showing.

Inboard.—From the side to the center of ship.

Intercostals.—Plates made in sections running fore and aft, fitted between floors. Opposite of continuous.

Joggle.—To bend over that part of a lap.

Jury Mast.—A temporary mast put in place of the one lost.

Keel.—The "backbone" of a ship. A series of plates connected, running fore and aft in the center of ship.

Knot.—A nautical mile of 6,080.26 feet, or 1.15156 statute miles.

Knuckle Line.—The dividing line between the upper and lower stern.

Landing.—The distance from the edge of plate or bar, to the center of the first rivet hole.

L. B. P. (Length Between Perpendiculars).—Measured from the forepart of the stem to the after end of the stern post.

L. O. A. (Length Over All).—Measured from the most forward part of the fore end to the most after part of the after end of the hull.

Lift from the Hull.—As a rule, templates are made for most plates and bars, but sometimes it is necessary to "lift," by placing a frame of wood around the opening for the missing plate, and when nailed, to transfer the holes of the adjoining plates by pencil mark, and when a sufficient amount of *landing* has been given, the plate should be the proper size.

Lightening Holes.—Holes in the floor plates to lighten the weight, also called man holes.

Liner.—A flat piece of iron or steel, tapered or parallel, to fill in space, caused by plate laps, etc., when a bar must be riveted at that point.

List.—To incline to one side, as the ship *listed* to starboard.

Load Water Line (L. W. L.).—A line painted on the side of the vessel to which the vessel sinks when carrying its full load.

Log Book.—Book with record of every occurrence and incident during the voyage.

Main Beam.—The one that is placed amidships.

Main Body.—The hull proper, without the deck-houses, etc.

Manhole.—Round or oval openings cut in the tank top, etc., to allow inspection.

Messroom.—The dining room for officers.

Midship.—Middle part of the ship's length.

Molded Depth.—Measured from the top of keel to the top of the upper deck beam.

Molded Line (M. L.).—The heel or working point.

Mooring.—Securing a vessel in position by cables or lines.

Mooring Pipe.—An opening in the bulwark to allow ropes, cables, for docking to pass through.

Net Tonnage.—The space below decks for cargo only.

Out Board (O. B.)—From the center to the sides of ship.

Panting.—Bulging in and out of a vessel's sides, caused by wave action.

Panting Beam.—In the fore or after peaks between decks.

Peaks.—After, forward ends of ship.

Plimsoll Line.—A circle, with line running horizontally through the center near the water line to indicate the limit of load. This line, according to Lloyd's, must not be below the water line.

Poop.—The structure or raised deck at the after end.

Port.—The left hand side of ship, looking forward toward the bow or stem.

Prick Punch.—A small punch used to transfer the holes from the template to the plate.

Reversed Frame.—A bar placed in a reversed position to an adjoining frame to give additional strength.

Rudder Pintles.—Metal pins used to connect the rudder to the stern post, and hold it securely while the rudder is being swung for steering.

Scarph.—A lapped joint made by bevelling off, nitching or otherwise cutting away the sides of two plates at the ends, and bolting or strapping them together so as to form one continuous piece, usually without increased thickness. Also spelled scarf.

Screen Bulkhead.—An arrangement to prevent the cold air from striking the boilers directly.

Scrieve Board.—A large section of flooring in the mold loft in which the plans of the ship are cut with a scrieve knife.

Scuppers.—Openings in the deck near the shell plating, to allow waste water to run overboard.

Scupper Pipe.—Pipe connected to scupper to allow passage of water, connected to run below decks, to prevent waste water flowing down the sides of ship.

Shaft Alley Tunnel.—An enclosure of water tight construction, extending along the middle of engine room bulkhead on tank top to the stuffing box, at the after end. It contains the shaft which is elevated.

Shape Strap.—A tapered bar used to protect the shell plate from the anchor chain, it is of such shape as to allow the chain to slide over it without catching on the plate or pulling the plate out.

Shelter Deck.—The top main deck in shelter deck vessels.

Shift of Butts.—The butts so arranged that there will be only one butt between the frames, if possible.

Ship's Log.—Book with record of every occurrence and incident during the voyage.

Skylight.—A framing constructed over an aperture in the deck, fitted with window glass and reinforced, to admit light below deck.

Sounding Pipe.—A pipe leading from main deck to double bottom, of sufficient size to allow a round piece of metal attached to a line to be lowered to ascertain the amount of water in the double bottom.

Soundness of Steel.—Absence in a casting of cavities or blow holes formed by air bubbles.

Square Body or Dead Flat.—The parts amidships forward and aft from the center of ship that are same in measurement.

Staggered or Zigzag Riveting.—Two rows of riveting with alternating spaces.

Starboard.—The right hand side looking forward, to the bow or stem.

Stem.—The bow of the ship—the part where the port and starboard meet, a massive curved shaped solid bar running from keel to forecastle deck.

Stern.—The after end of the vessel.

Stern Pipe.—A pipe leading to the opening at the side of poop deck for passing through of cables, chains, etc., for mooring purposes.

Stern Post.—A massive casting of special design, shaped to allow the propeller blades to revolve. The rudder is fitted on the after post.

Strake.—A continuous row of plates running fore and aft.

Stringer.—A bar, angle.

Telegraph.—Installed on the captain's bridge and engine room for quick communication.

Toe.—The end of a flange on a bar.

Tonnage.—A measure of a vessel's interior volume, 100 cubic feet containing a ton.

Transom Plate.—The plate between the fantail and the hull.

Transverse.—The frame or rib of a ship.

Trimming Tanks.—The peak tanks, at the after and fore ends.

These are very essential to a vessel. By filling the after peak tank and emptying the fore peak tank, the stern is thus lower in the water, and vice versa. It is recorded that a ship with little ballast, during a storm, was in danger of going ashore, on account of the propeller not being entirely submerged, and, therefore, not getting the required resistance. The Captain, by filling the after peak and emptying the fore tank, got more resistance from the water, and finally reached the open.

Veer.—The wind to veer, to change.

Wake.—The motion of water left by a moving ship.

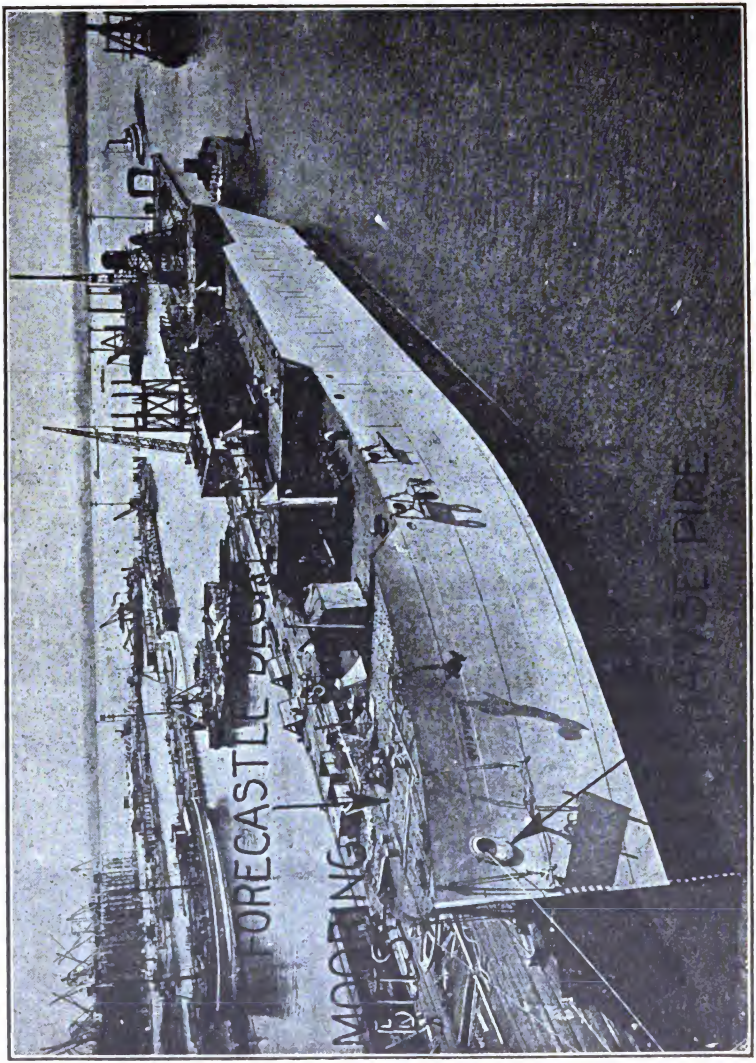


Fig. 9.—Ready for outfitting.

Water Ballast Tanks.—Tanks in the double bottom used for ballast.

Waterlogged.—A ship full of water, but afloat.

Weather Deck.—The upper deck.

Web.—The part connecting, or between the flanges of a channel bar.

Weigh Anchor.—To lift anchor off the sea bottom.

Weld.—To join two parts of steel together, without the use of rivets.

Zenith.—When the sun is in the zenith and observed with a sextant, the arc will be 90° from the horizon.

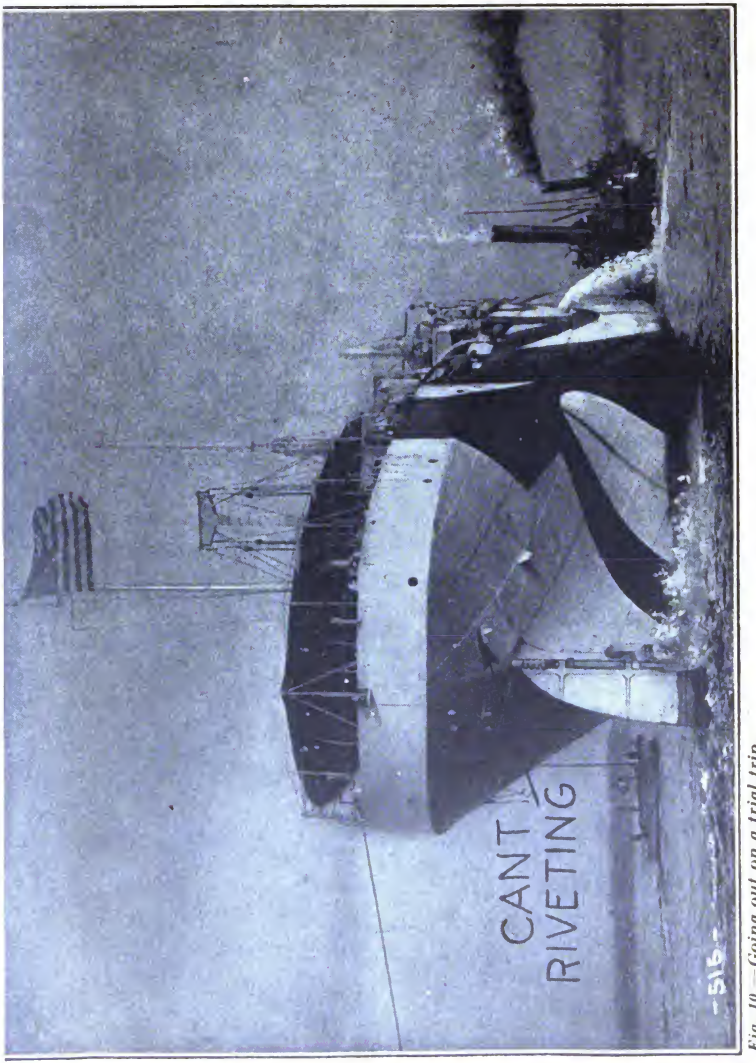


Fig. 10.—Going out on a trial trip.

A SHIPFITTER'S DUTIES

The work of the shipfitter (sometimes called "fitter-up") consists in marking off the steel material for different parts of the ship's hull, including plates and the various shapes such as angles, channel bars, etc.

He also marks the rivet holes to be punched. Besides, he assembles all plates, bottom frames, side frames and brackets for bilge and decks, water-tight and non-water-tight floors and bulkheads, clips for the vertical keel, longitudinal stringers and brackets. He also lays out deck plates and tie plates, clips, angles and beams for inner bottom plates and angles and all foundation work.

The most difficult problems encountered in shipfitting are found in the auxiliary foundations, gun foundations, deck housings, shell plating, otter gear, etc. There is also a variety of hole spacing to contend with, such as is found in water-tight work, oil-tight work, etc.

Laying out of bracket clips is a slow but simple operation.

The laying out of stringer plates is a fairly accurate and somewhat complex operation.

The laying out of plates with flanges is complex and requires a great deal of accuracy.

The lifting of a shell strap. The operations for this work are simple and must be thoroughly accurate.

The lifting of an angle ring for a mast is complex and requires the greatest accuracy.

Mast building is also a difficult job.

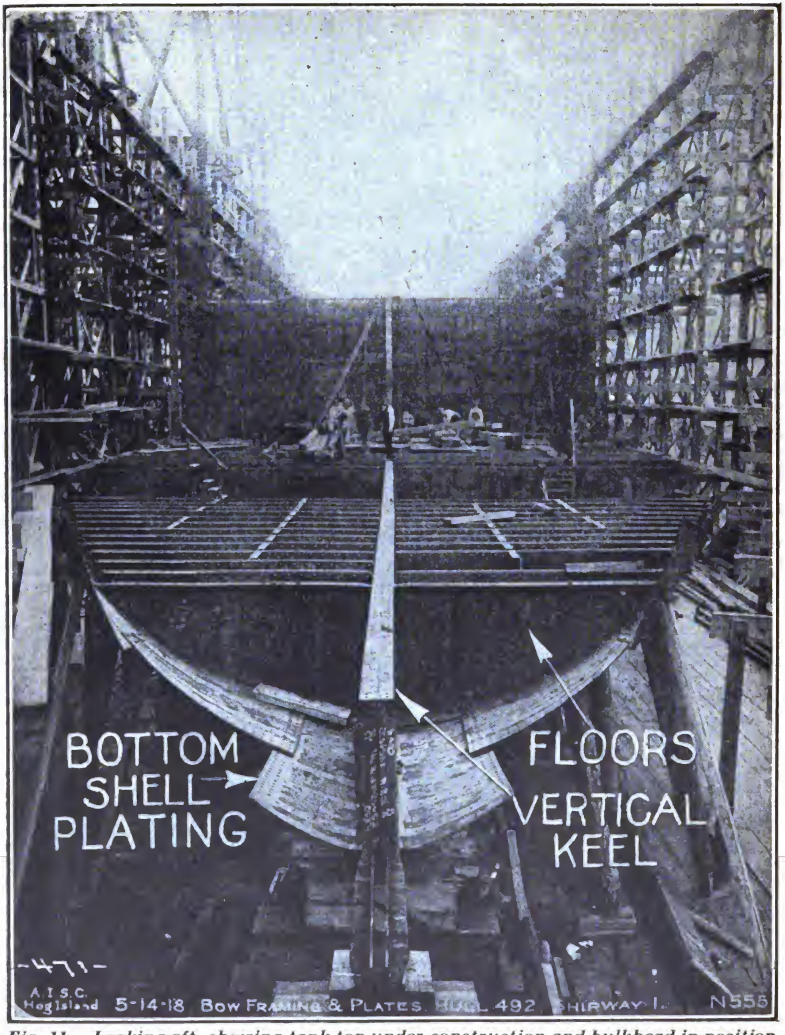


Fig. 11.—Looking aft, showing tank top under construction and bulkhead in position and bow framing.

Lifting of dynamo flats. This, also, is a complex operation and requires a great deal of close attention and accuracy.

Putting in a shell liner. This operation is simple but rather slow.

Laying off liners with mold loft templates. This is a simple operation and can be done in quick time.

The making of templates for staples, lifting bevels, laying off of same, requires a good deal of skill and much accuracy.

The shipfitter must be on the job to show the erectors where to place the material for the construction of a particular job, wherever it is to be erected.

The shipfitting department is the most important branch in the yard. Shipfitters must rectify the mistakes of the draftsmen, loftmen, layers-out, carpenters and punchers.

Skill in shipfitting consists in knowing where and how to place the proper iron plates, flanges, brackets, bars and make the templates for all adjustments, and in working out problems from blue print drawings and sketches, but he is an important man to shipbuilding who can put in liners and put them in right.

As in all trades, there are certain short cuts or kinks in shipfitting.

The shipfitter's ability to visualize his work while laying out his material is a gift which enhances his individuality as a shipfitter.

Shipfitters often become very efficient loftsmen.

The marking off of the steel material for different parts of the ship's hull is often done by means of a template lifted or marked off from other parts already in place on the ship. In some cases, the material is marked off directly, without the use of a template, from dimensions taken from a blue print or other plan.

It will thus be seen that there are three different ways of marking material for fabrication:

1. From templates made in the mold loft by the loftsman.

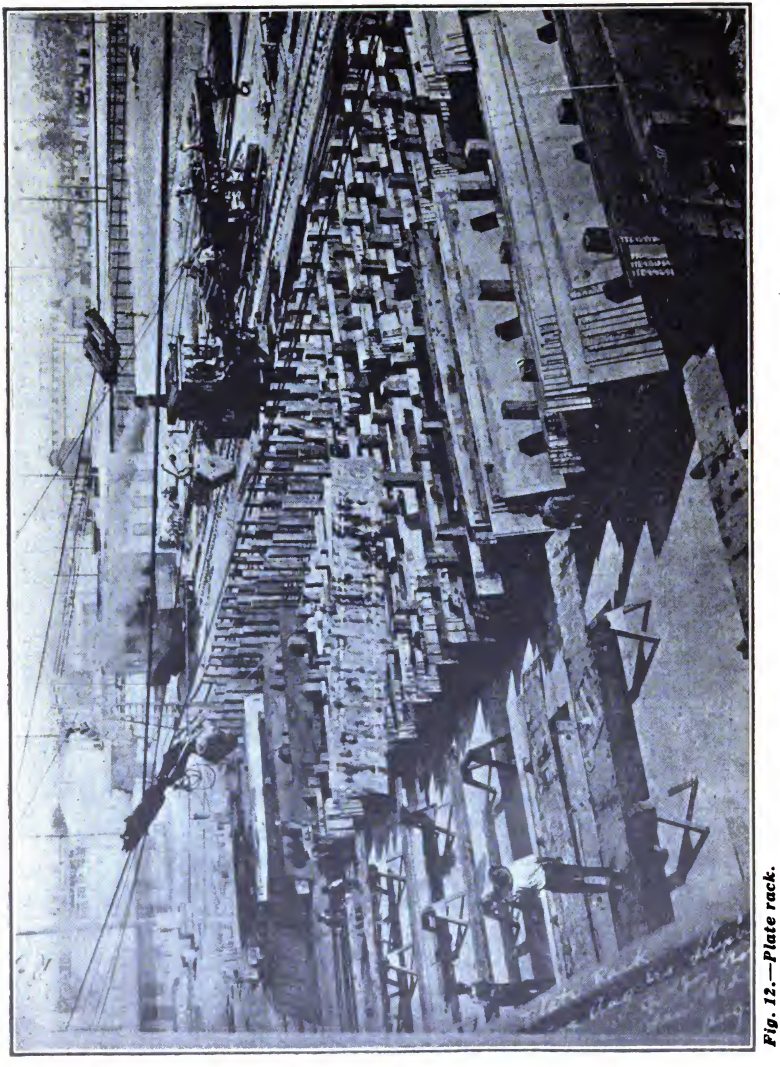


Fig. 12.—Plate rack.

2. From templates made on the ship by shipfitters.

3. From blue prints, directly, by shipfitters.

The amount of material marked off in each of these three different ways varies in different shipyards, according to yard practice.

There is a wide variation in the methods of various yards and sections in the construction and use of templates.

There is always something new to learn about the shipfitting trade because of the many different problems that are presented on ships of different construction. This makes the trade very interesting and attractive.

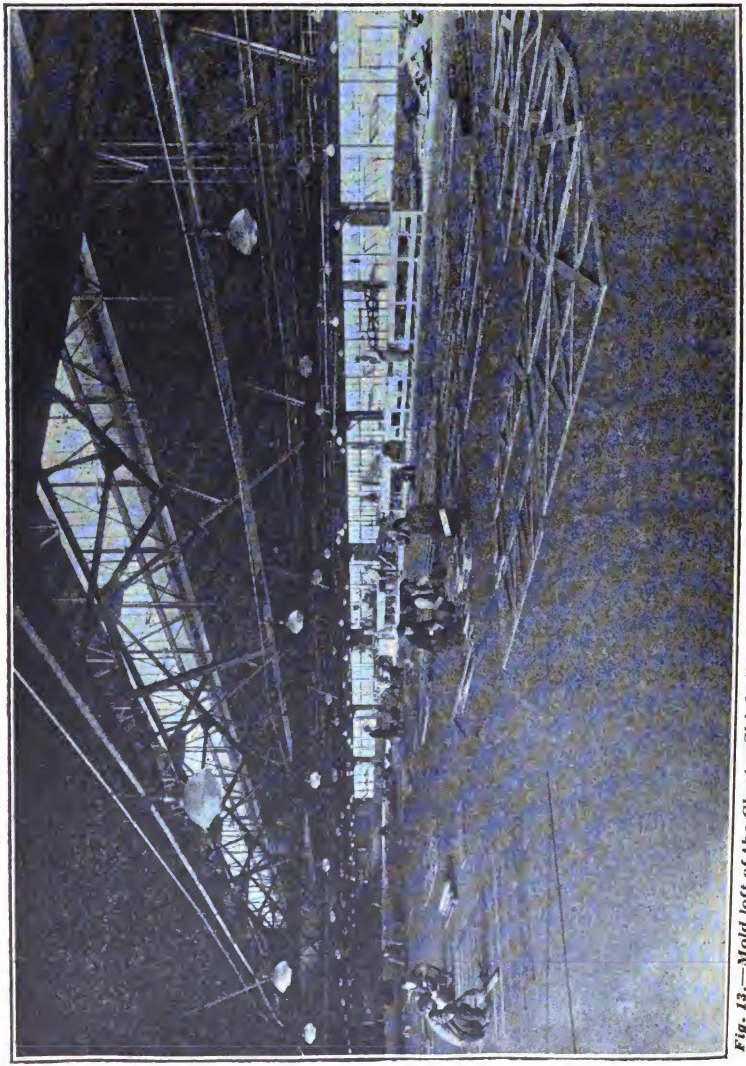


Fig. 13.—Mold loft of the Chester Shipbuilding Co.

THE MOLD LOFT

All shipbuilding yards have a special building or loft called the "mold loft" on the floor of which the designs of the ship are laid off in order to determine the exact dimensions of the various parts of the ship.

In the mold loft the ship parts in blue print form are laid out in the actual size of the ship which is to be built. The loft usually occupies the top floor of the largest building in a yard. It may be one hundred or more feet wide and as much as six hundred feet long. It may be large enough to take the entire plan of a great passenger liner or battleship. When smaller ships are being constructed in a yard plans for several are frequently laid out in the loft at the same time, and if standard designs are being used, patterns are produced in duplicate.

Some yards have small mold lofts as well as one large one, so that plans for parts of ships may be handled at the same time that work is going on in the main loft.

The loft has an especially prepared smooth floor of wood, upon which patterns are expanded and marked out with extreme care, so that the parts of even the largest ship, after fabrication, will fit together perfectly. The flooring is well matched and fitted; and all nails or screws sunk below the surface and the holes filled in so as to have a very smooth surface.

The work of the mold loft is to make molds, or "templates," as they are called in the yard, of heavy paper and of thin wooden boards, from drawings or blue prints, for all the structural parts of a ship.

A template for a steel plate consists of a full-size pattern of the plate, marked out and showing in detail all punched or countersunk holes and scarphs, bends and angle lines. In making templates some yards use paper extensively. This has some disadvantages, as the paper contracts or expands so much that it is sometimes necessary to make many corrections on the ship.

Templates of basswood or white pine are better, and can be easily stored.

The shipbuilding company has a schedule of dates for laying the keels of ships.

The mold loft receives these schedules and the drawings for the parts of each ship from the hull drafting department. First a "line plan," or plan for line work, is drawn up. From this is laid out upon the floor a full size working body plan for the ship.

From these lines in body plan are developed the structural portions of the ship.

Eight or ten plans may be on the floor at one time, such as the outer shell, decks, inner bottoms, bulkheads, frames, etc. All measurements and details for body plans for the guidance of loft-work are found upon the blue prints or drawings supplied to the loft.

Each template laid out upon the floor is checked up from the blue print.

The division of workers in the mold loft is as follows:

Superintendent loftsman, foreman loftsman, quartermen, leaders, loftsmen, helpers, men in charge finished templates. The drawing of lines upon the floor to full size from offsets furnished by drawing room is the central and most important part of loft work.

The word "loftsman" is the distinctive name of the person who does this work. He must be the one who thoroughly understands blue print reading, and who can do a first-class structural job in the loft. In many yards he is called a "linesman."

Except on small jobs, men in the mold loft work in groups or gangs, named after the most important parts of the ship. Thus, the "framing gang" makes molds for all framing parts, and the "deck gang" makes deck templates, "shell gang" making sheli templates.

The making of molds from the lines on the floor is skilled work in wood. It may be done by an ordinary carpenter, but calls for great carefulness and exactness.

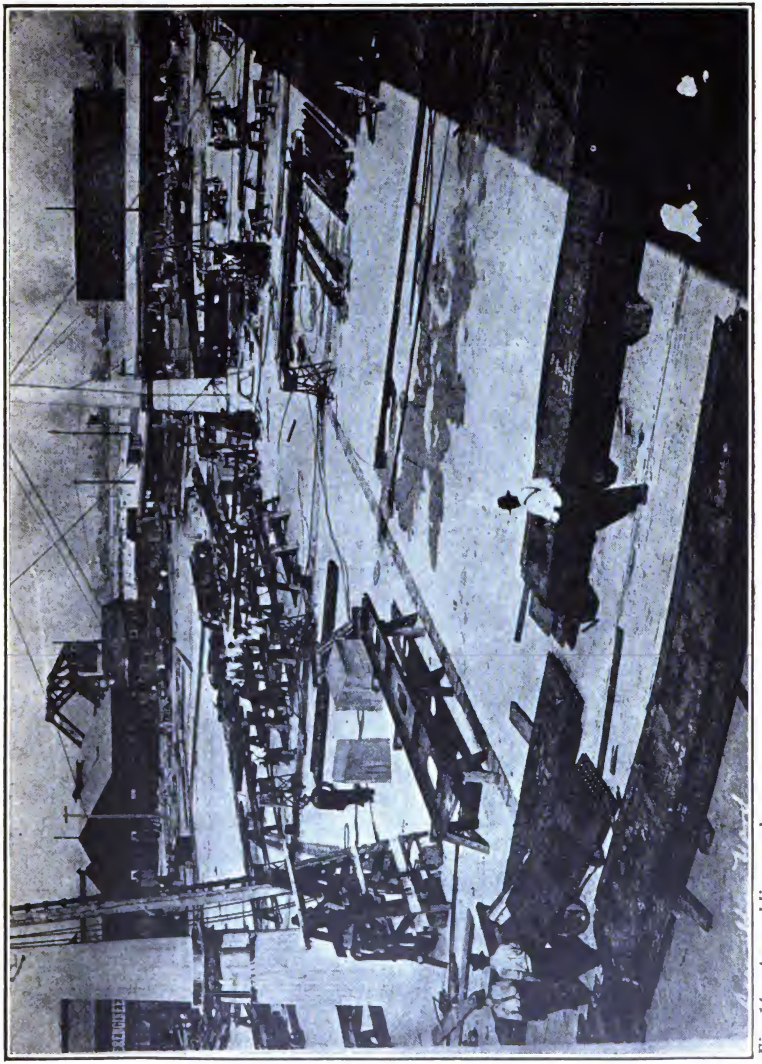


Fig. 14.—Assembling yard.

The Scrieve Board.—When the drawings of the ship's parts are laid out on the floor to actual size intended for construction on the ways, the frame, tank top, tank margin, deck heights, seam laps, and longitudinal lines are cut in the floor with a scrieve knife, so they cannot be easily erased. This floor is called the scrieve board.

The right side of the scrieve board is called the *fore body*, because the lines of the fore body are laid down on that side, and similarly the left side is called the *after body*.

It is from these drawings on the floor that the templates or patterns of the ship are made.

FROM THE LOFT ROOM TO THE HULL

Before beginning the practical study we shall take an imaginary trip through the yards to give you an idea of the course the results of your labor will take.

The blue prints are taken from the drafting room to the mold loft man, who takes the various templates out of stock or has them made.

They are then taken to the duplicating shop. Here they are assorted into various groups. The layersout and shipfitters get the templates and transfer the outline and the holes of the templates to sheet steel; the same operation whether for a shell plate, angle or channel bar, etc.

The template is fastened to the steel plate with iron clips all around the object, so that it cannot move. An impression of the holes is made on the plate with a prick punch. After the lines and position of the template are accurately transferred, the template is removed from the steel and the impressions of the holes are made larger and clearer with a center punch.

The use of the template is no longer required, so it is sent back to the loft room where it will be kept in reserve until needed again.

The transferred plate is then sent to the punch shop. The

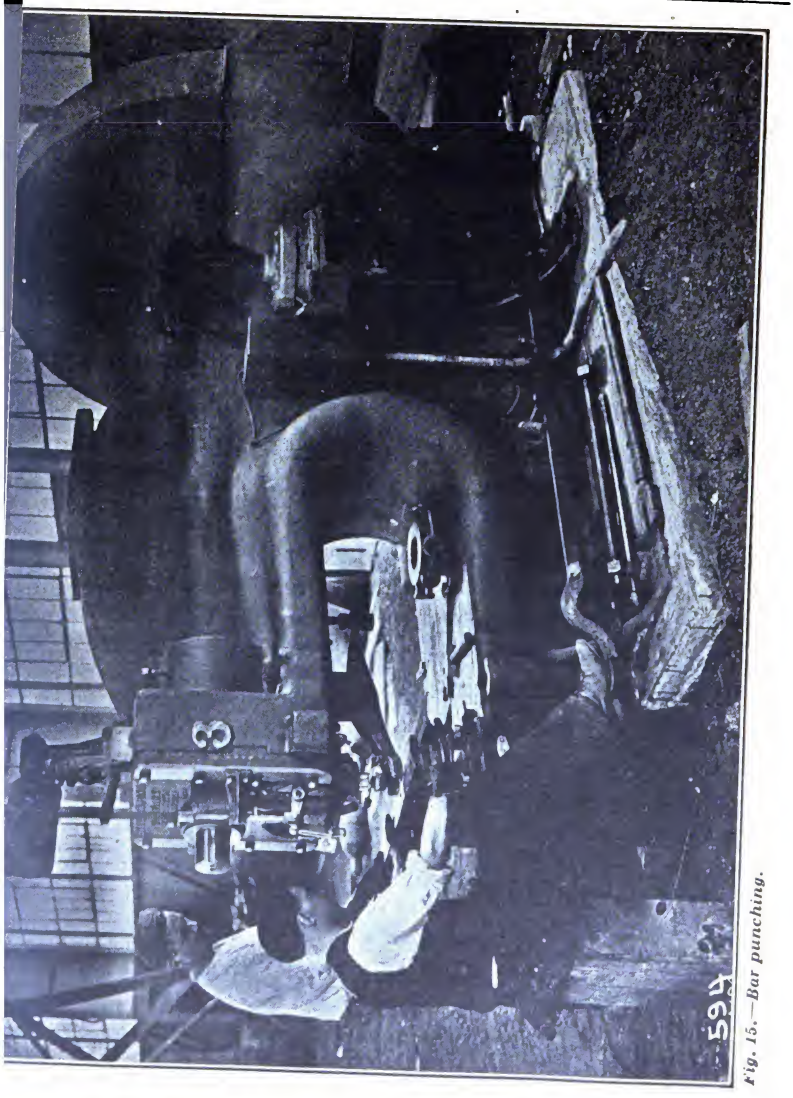


Fig. 15.—Bar punching.

following operations are not for a shipfitter, but we shall follow the course of the plate.

In the punch shop the plate is placed in position and held by clamps supported by pulleys while being punched.

The center of the machine punch is placed over each mark intended for a rivet hole, and is then punched out. Some parts of the plate or bar are marked C S K, which means to countersink or bevel the holes so that the rivets will come flush with the plate or bar.

The plate is then sheared (S) or cut, and the edges planed straight and smooth and scarphed for butt laps. It is then ready to be placed on the ship, unless it is of special shape or form. The plate is then put through the rolls or if an angle or channel, etc., is sent to the blacksmith shop. When placed on the hull, it is held in position by powerful cranes, and the slinger temporarily places bolts here and there through the rivet holes, and nuts are screwed on the bolts, so as to keep the plate in place for the riveter.

Often on a shell plate, angle, channel, etc., the rivet holes do not meet, the holes being "unfair." In that case there has been a mistake made with the drill holes in the template or in bolting up.

Suppose that shell plate No. 1 is joined to shell plate No. 2 and longitudinal No. 12 running fore and aft crosses both shell plates. You will readily see that a rivet will have to go through three sets of holes, and if the holes do not meet it will be impossible to place the rivet in position.

You will immediately be notified of the trouble and you will get your templates of both No. 1 and No. 2 and of longitudinal No. 12, you will place them on the floor to see if the holes match. If a mistake, it must be corrected at once, but if found that the

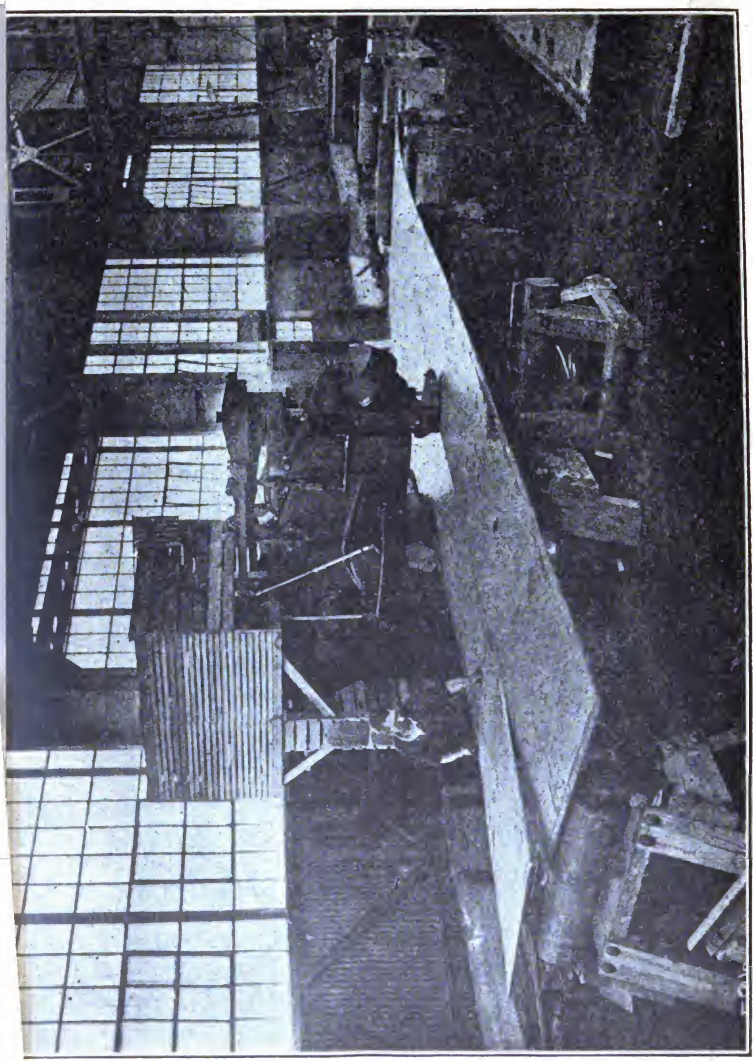


Fig. 16.—Shearing machine for plates.

holes run true, it must be the fault of the duplicating or punch shop,—accuracy must always be observed.

Progress of raw material through the punch shop—The following system is used at the Chester Shipbuilding Company's yards:

Liners, Angles, Channels and Plates—Liners are received at the middle door of the punch shed, spread out in Bay 3, laid off by linermen, carried by hand to Bay 1, cut according to specifications and carried by shipfitters and helpers to the ships where they are used in the different sections.

The angles are received at middle door, certain lengths are heated and beveled according to specifications, carried by crane to Bay 3, laid out by layersout and distributed to various punches, after which they are loaded on cars and shipped to various sections.

Channels are received at the middle door, sent to furnace, heated, beveled and molded into various shapes. The layersout lay off this material, transferred by crane and truck to various bays, where it is punched at machines then shipped on cars to different boats.

Plates are received at end door of punch shed, track 32. The donkey crane transfers both shipfitters' and layersout plates to eight different racks. Layersout and shipfitters lay off material. It is then carried by crane to punches, shears and planers and then carried to cars and shipped to the boat.

Material Punching System in the Punch Shop—The production department has checkers in the shed checking the progress of each piece of material. When the plates, angles, channels, and "flats" are received, they are checked piece by piece, a card is attached to the iron and as the iron passes through the furnace, anglesmiths, laying off, punch, shear and planers the cards and checkers follow up until it is finally received on the boat.

Scrap—This material accumulates as waste from different grades of material. If sufficiently large it is returned to stock by foremen in charge, who notify both the planning and raw material departments of the return and attach return to stock slips.

The remaining scrap is wheeled by laborers to the middle door of Bay 1. Here this material is thrown in a heap and mechanics utilize it by making it into brackets, small jobs on P. D. orders, angleclips, liners, rings, shin plugs, packing ballast and weight.

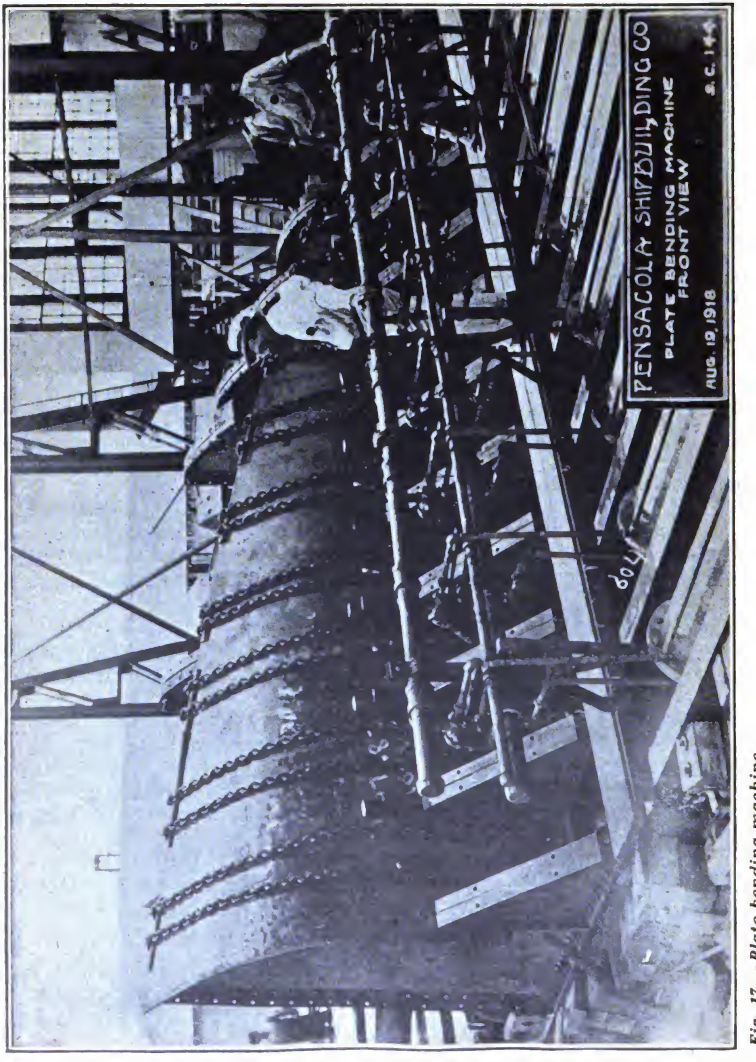


Fig. 17.—Plate bending machine.

PLAN READING

It is impossible in a work of this size to give a lengthy treatise on blue print reading for shipfitters, but the following will give the reader a general idea of the subject.

The secret of understanding how to read a drawing lies in being able to see in the mind what the object represented by the working drawing looks like.

The drawings for many parts of a ship are similar to those made for any structural work.

The purpose of a blue print is to give the loftsman the information necessary to construct the templates. Detailed drawings are given of the vessel, which represent it in an unmistakable manner, giving dimensions of all the parts and containing all information required.

The dimensions given are for the finished sizes of the parts, that is, the dimensions for the work when it is completed. Consequently all the figures written on the different parts indicate the exact size of the parts when finished without any regard to the size of the drawing itself, which may be made to any reduced and convenient scale.

Blue prints are used in all mechanical trades, and it is necessary that they are understood thoroughly in order to work quickly and accurately.

All measurements and details for the guidance of loft work are found on the blue prints, and each template laid out upon the floor is checked from the blue prints.

A drawing termed the "lines" is worked out on a small scale, usually one-quarter inch to the foot, which is $1/48$th the actual size. This drawing consists of three views:

1. Profile, or so-called sheer plan.

This is the shell expansion or longitudinal elevation showing details of shell.

2. Half-breadth plan.

A top view of one half of the ship, divided by a vertical longitudinal section through the axis of the keel. It shows the water line, bow and buttock lines, and diagonal lines.

3. Body plan.

An end elevation showing the water lines, buttock and bow lines, diagonal lines, etc.

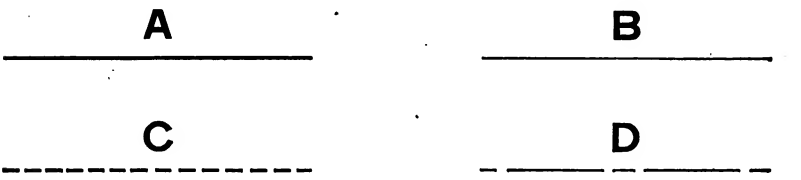


Fig. 18.—Various lines used in drafting.

Straight lines in one view are contour lines in another, so that the vessel's form is fully delineated.

Blue prints are made of these drawings and are sent to the mold loft. These plans are drawn to full size on the mold loft floor, and this is the most important part of loft work.

The man who does this work is called the "loftsman" or "linesman" and he must thoroughly understand blue print reading.

A number of detail drawings are also given to the loftsman, which contain all necessary information for the mold loft for the making of the templates or for the iron workers to lay off material and fit it on the ship.

For a 9,000-ton ship, the structural plans comprised 35 drawings for the main structure and 5 for the superstructure.

The full line A, in Fig. 18, is used in making the outline of the various views of the drawing and all parts which can be seen with the eye.

The full light line B, Fig. 18, is generally used for dimension lines on a drawing, as in Fig. 24.

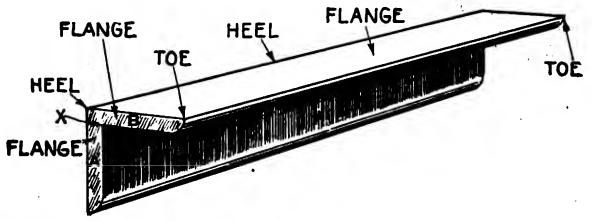
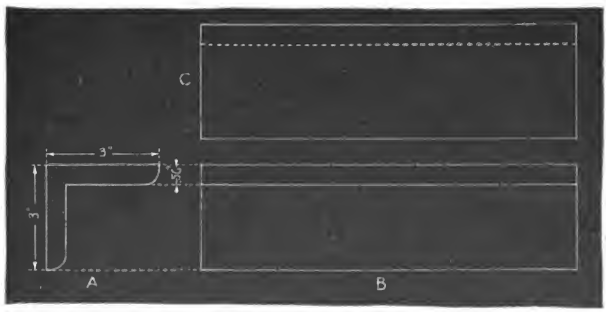


Fig. 19.—Angle Bar.



Figs. 20 to 22.—Blue Print of fig. 19.

The dotted line (short-dash line) C, Fig. 18, is generally used to indicate invisible parts, as in Fig. 22. This line is sometimes used to connect views of a drawing and is sometimes used as dimension lines.

The dot and dash line D, Fig. 18, is used to represent the center line of an object.

Arrow points show from what points distances are measured.

The mark (′) represents feet, as 9′, and the mark (″) represents inches, as 9″.

Fig. 19 is an angle bar, the dimensions of which are 3×3× .56

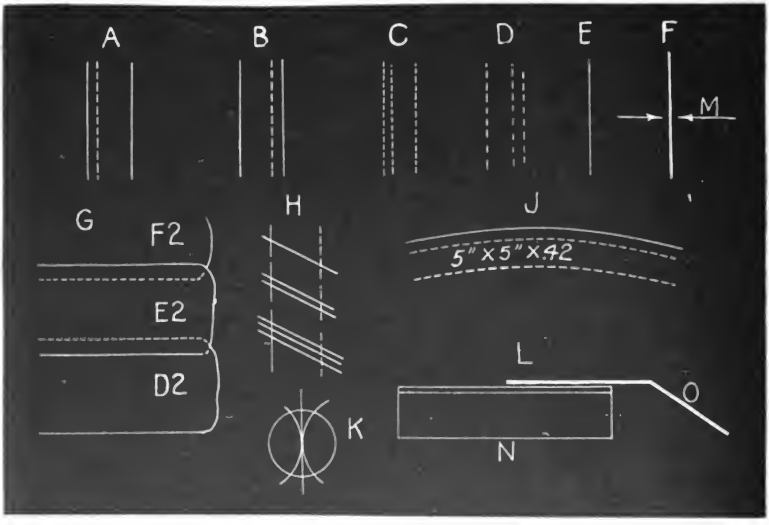


Fig. 23.—Blue print chart.

which means that the flanges A and B, are each 3 inches long and .56 of an inch thick.

Figs. 20 to 22 represent a blue print of the angle bar.

A is end view of the angle bar.

B is side view of the angle bar.

C is top view of the angle bar.

The dotted line in the top view, Fig. 22, represents the edge

X, which is not visible to the eye when looking at the top. By this line, one is able to distinguish which is the *heel* edge of the angle, see Fig. 23.

In Fig. 23, A and B, show an angle bar. A, shows the heel to be on the left, and B, the heel to the right.

C and D, show a bar, underneath the deck, the dotted lines representing an invisible object. The heel of C bar is left and in D the heel is on the right.

E—A frame or transverse.

F—A heavier line than E, showing position of bulkhead; M, represents a longitudinal terminating at bulkhead, as shown by arrow points.

G—On shell and deck drawings, etc., arrangement of plates, showing seams, Plate E2 lies on the edges of plates D2 and F2. The edges of the underneath plates shown by dotted lines.

H—Shows lines indicating number of rows of riveting. One line indicates single riveting. Two lines double riveting, etc.

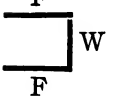
J—Showing an angle next to shell. The size, 5 inches by 5 inches by .42 of an inch, signifying an angle; if it were marked thus, 7 inches by .40 of an inch by 3½ inches by .42 of an inch, it would be a channel bar.

K—Exact center of ship, as in the midship drawing.

L—Shows a clip N, with a bracket riveted to the flange of clip, as shown by heavy line O.

CHANNELS, ANGLES, ETC.

Channels.—The parallel lines, F F, are known as the flanges; the line W, connecting the flanges is the web. The corners or points at the intersection of the flanges and the web is the heel. The ends of the flanges are called the toes.



Angles.—The lines, F F, are known as the flanges. The corner is called the heel and the ends of the flanges are the toes.

Although there are other bars of various shapes, the above are the most generally used.

PLATES

The plates are in "strakes" or rows running fore and aft and beginning from the flat keel the strakes are numbered as follows:

The first strake (the garboard strake) is marked A, the next B, and so on up to the gunwale.

The letter I is not used.

The plates are numbered 1, 2, 3 and so on, from the after end to the fore end. Thus, a plate marked C 6 must be three strakes up and the sixth from the after end.

In Fig. 24 the plates are marked H 10 and H 11, J 10 and J 11. These are called the order marks.

Fig. 24 represents a blue print of a section of the shell. The laps of the plates are shown and dimensions are given showing the width of the laps and number of rows of rivets. The heavy line represents the bulkhead. The order marks and thickness of plates are shown, also the width of plates.

The longitudinals are marked S 1 to S 5; note that none break through the bulkhead, shown by arrow points on both sides of the bulkhead.

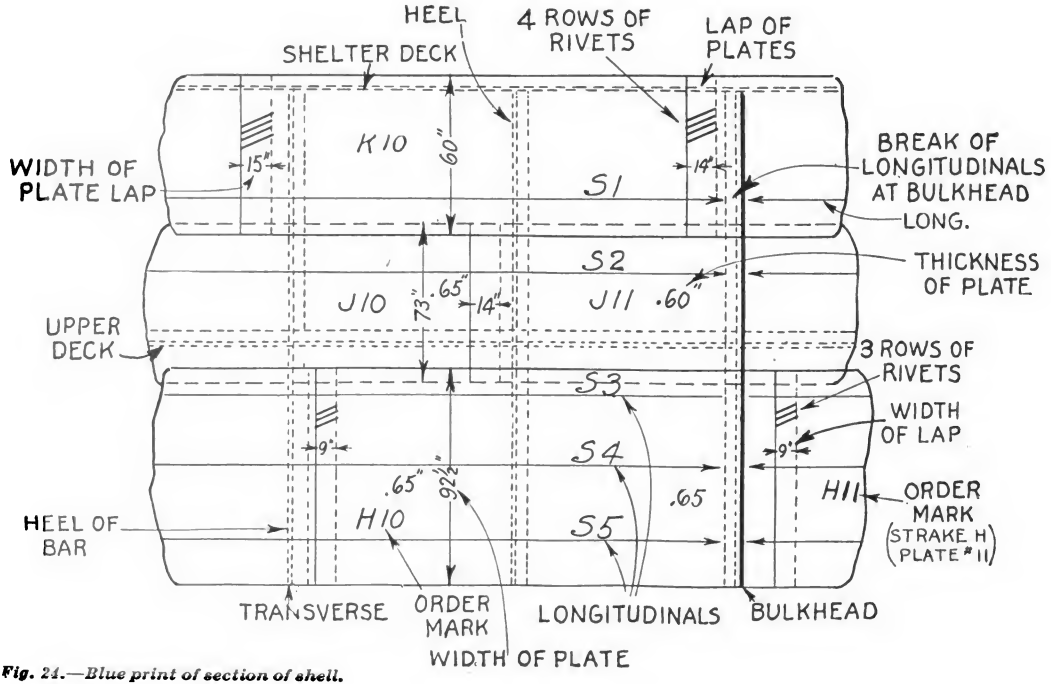


Fig. 21.—Blue print of section of shell.

Heel shows position of channel or angle, the double line representing the heel.

The shear mark is shown at D. The number of rows of rivets is shown by parallel lines. The width of the plates is shown on vertical dimension lines.

THE AFTER BODY

Flat Keel.—The flat keel is shown on the bottom of the after section No. 1 and No. 2, between frames No. 4 and No. 13. (See Fig. 25.) The plate No. 1 at the after end is made of special steel, which is known as flange steel. The end is knuckled up, so as to allow the stern post to fit in snugly, and to which it is riveted.

A Strake.—The plates above the flat keel are known as A strake or garboard strake. This strake A, is termed the skin strake on account of being an inner strake. Longitudinals No. 17 and No. 18 are in this strake and begin at frame No. 13.

B Strake.—This strake, which is above A strake and is similar to the A strake, is an outer strake. Longitudinals No. 15 and No. 16 begin at bulkhead No. 11, and on account of being a water-tight compartment, these and all longitudinals begin at that point and are bracketed, so as to impart additional strength to the bulkhead. Plate No. 1, between frames No. 4 and No. 7 is cut out, to allow for the shape of the boss plate.

C Strake.—This strake is a skin or inner strake and the same applies for this as the B strake. Longitudinals No. 13 and No. 14 also begin at the bulkhead No. 11 and bracketed.

Boss plate is between B and C strakes. This is a strake or patch plate. It is one of the most difficult plates to lift from the ship.

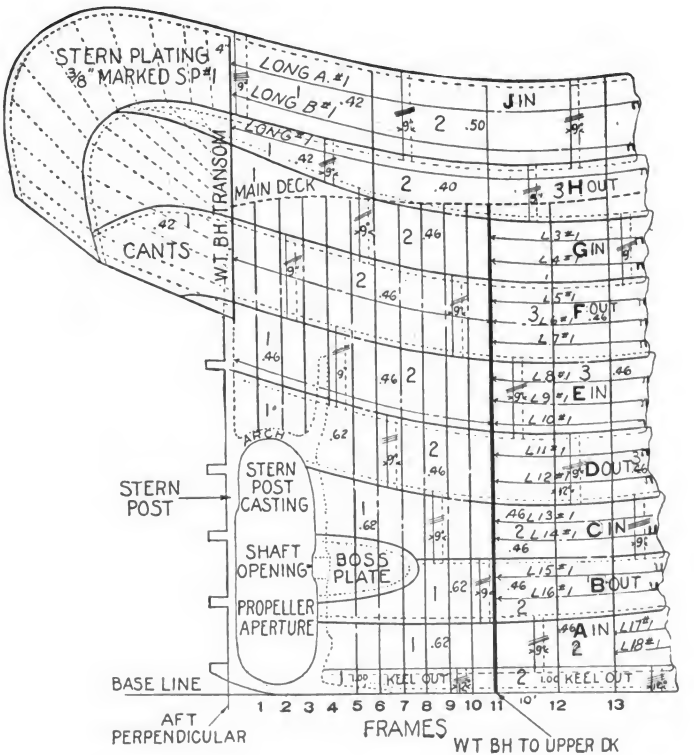


Fig. 25.—After body (shell).

D Strake.—This strake is an outer strake and takes in longitudinals No. 11 and No. 12.

E Strake.—This is an inner strake. Longitudinals No. 8, No. 9, No. 10. Plate No. 1 is called the oster plate. This plate connects to the cant frames.

F Strake.—An outer strake. Longitudinals No. 5, No. 6, No. 7.

G Strake.—An inner strake. Longitudinals No. 3, No. 4. It will be noticed that the line of the main deck extends through No. 1 and No. 2 of this strake.

H Strake.—An outer strake. Longitudinal No. 1, beginning at the transom floor. The line of the main deck also passes through plates No. 2 and No. 3 of this strake.

J Strake.—The top or shear strake. Longitudinals A and B extend from the transom floor.

Fan Tail.—At the after end or stern of the ship, it is composed of cant frames and stern plating.

It derives its name from the well-known breed of pigeons, the fan tails. Cant frames, derive their name because of the fact that they do not rest square to the keel.

Stern Plating.—Begins at the after end of strake J, plate No. 1, and extends around the cant frames.

Transom.—A water-tight floor or bulkhead, dividing the fan tail from the hull. The stern post is riveted to the transom.

Frames.—The numbers 1 through 10, inclusive, at the base on floors, which reach to the main deck.

It will be observed that frames No. 1, No. 2, No. 3 and No. 4 start from the stern post. Frames No. 5, No. 6 and No. 7 are boss frames. Frame No. 6 is a transom above the main deck. Frame No. 11 is a water-tight bulkhead to the main deck, and above it is known as a transverse. Frame No. 13 is the transom.

Stern Post.—This is a casting of special design. The propeller; the keel, plate No. 1; strake A, No. 1 plate; strake B, No. 1

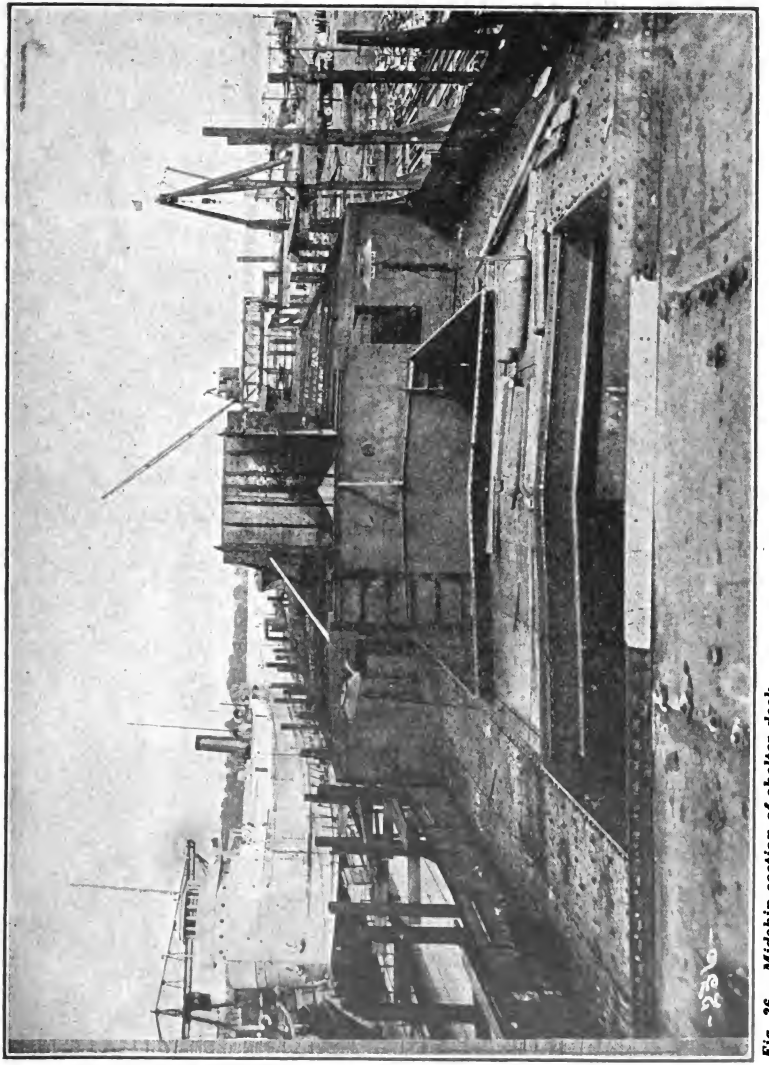


Fig. 26.—Midship section of shelter deck.

plate; strake C, No. 1 plate; boss plate; strake D, No. 1 plate and strake E, No. 1 plate are all riveted to the stern post. At the after end of the stern post are the projections for the rudder.

THE MIDSHIP SECTION

The midship section of the shell expansion, Fig. 27, is that part of the shell between the after body and fore body; beginning at the keel plate, which is the bottom plate or strake, as follows:

Keel (out).—Only half of this plate is shown in the drawing—unless otherwise noted, the other half is the same.

A Strake (in).—This is the next strake to the keel. On boats with a hanging keel it is called the garboard strake.

B Strake (out).

C Strake (in).

D Strake (out).—This is the bilge strake. The bilge keel is on this strake.

E Strake (in).

F Strake (out).

G Strake (in).

H Strake (out).

J Strake (in).—This is the sheer strake.

These strakes comprise the shell plating of the hull, and they are numbered from the after end to the fore end of the ship. The thickness of each plate is also shown.

The next plate above the J strake is the bulwark plate. It

does not extend the full length of the ship. Its name has come down to us from antiquity.

On the top of this plate is a bulb angle, which is called the bulwark rail. The boat deck supports or stanchions connect onto the bulwark plates, the boat deck being above these supports.

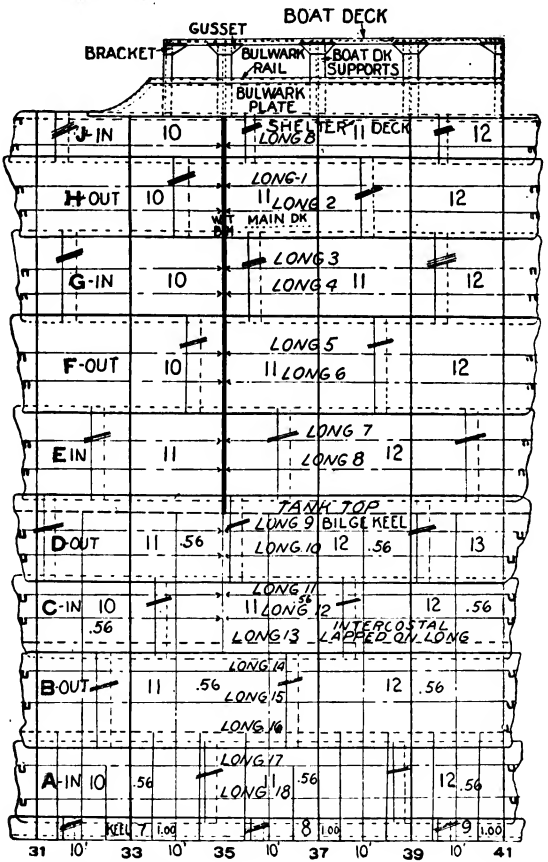


Fig. 27.—Midship section (shell).

The shell longitudinals number from the top of the ship down to the keel.

In strake A, longitudinals 17 and 18 run.

In strake B, longitudinal No. 16 is an intercostal girder.

This is shown by dotted lines. Longitudinals No. 14 and No. 15 are also shown in this strake.

Strake C, longitudinal No. 13; this is an ordinary longitudinal with the intercostal plates lapping; that is, connected onto it. Longitudinals No. 11 and No. 12 are also shown in this strake.

The top line in strake D is a line of the tank top margin bar; below this is longitudinal No. 9, which is also the line of the bilge keel. Below this is longitudinal No. 10.

Longitudinals No. 7 and No. 8 are in strake E.

Longitudinals No. 5 and No. 6 are in strake F.

Longitudinals No. 3 and No. 4 are in strake G.

The bottom line in strake H is a line of the main deck.

Longitudinals No. 1 and No. 2 are also in this strake.

The top line in strake J, is line of the sheltered deck; below this, is longitudinal B.

The vertical lines from the keel to tank top and shelter deck are the frame lines No. 31, No. 33, No. 35, etc., a floor extends to the tank top, from the tank top to shelter deck. Transverses No. 32, No. 34, No. 36, No. 38 and No. 40 are floors. These lines stop at the tank top.

Number 35 is a water-tight floor to the tank top. Above the tank top it is a water-tight bulkhead.

All longitudinals stop and are bracketed to this floor and bulkhead.

THE FORE BODY

Flat Keel.—Strakes A, B, D, E, F, G, H and J, in Fig. 28, are similar to the midship and after sections.

Strake C, does not show in this drawing.

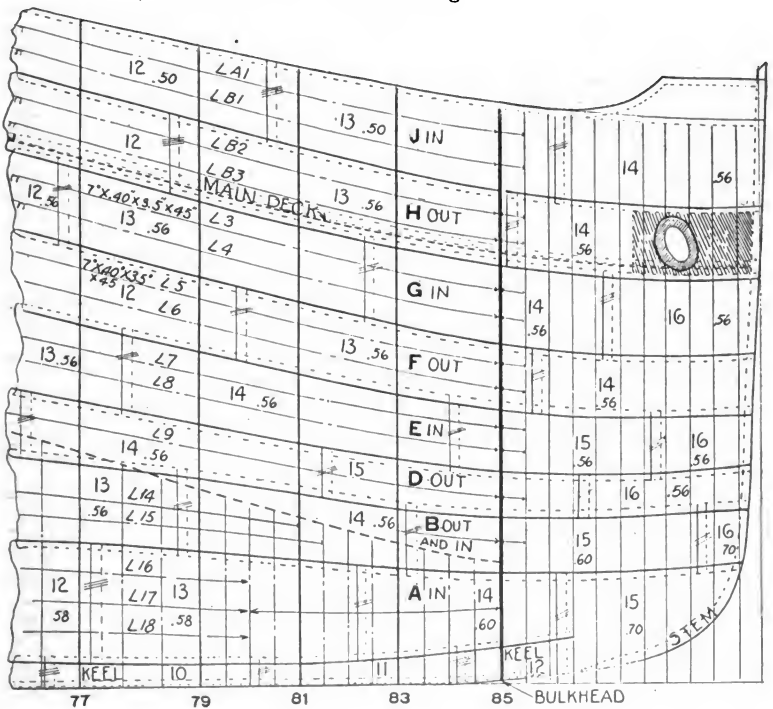


Fig. 28.—Fore body (shell).

Strake H.—Plate No. 14 in this strake, is the last plate near the stem, in it will be found the hawse holes; also shaded portion, indicating a doubling plate.

Stem.—Is shown at the extreme end by a dotted line.

Forecastle Deck.—Situated above this part of the hull.

The following plates are examples of midship cross sections showing different constructions:

Plate 1.—Midship section of the freight steamers, "Col. James M. Schoonmaker" and "Wm. P. Snyder," built by the Great Lakes Engineering Works.

The vessels are 617 feet in length over all, with a gross tonnage of 15,161, the molded beam being 64 feet and molded depth 33 feet. The hull is of arched girder construction, the cargo hold being divided into three compartments. Hopper sides are carried throughout the hold in a prolonged slope from the tank top to the main deck, forming side tanks 12 feet wide at the bottom and 5 feet wide at the top. The double bottom is 6 feet deep.

Two extra longitudinal girders have been fitted on the turn of the bilge in the water bottom to secure additional strength. All deck beams run fore and aft and are 13 inches deep with a 4½-inch flange ⅞ inch thick. All the frames are joggled, thus eliminating the use of liners back of the shell plating. Screen bulkheads are built on the box girder system.

Plate 2.—This is the midship section of the three sister ships, the "Yaque," "Yuna," and "Inca," built by the Great Lakes Engineering Works for the Clyde Steamship Co.

These were built for a special trade among the West Indies, which limited the draft to 15 feet.

The deck is supported by girders and a single row of wide-spaced pillar stanchions, leaving the holds practically unobstructed. The cargo holds have wood ceilings on the tank top and cargo battens on the sides. Aside from this there is practically no wood used in the ship.

Length over all is 258½ feet; molded beam is 38 feet, 3 inches; molded depth is 18 feet.

Plate 3.—Midship section of the Great Lakes bulk freight steamer "J. H. Sheadle" which is 550 ft. over all, 530-ft. keel, 56-ft. beam and 31 feet deep and is built on the arch girder system with straight hopper sides.

She has a water-tight bulkhead 32 feet aft of the collision bulkhead forming the forward end of the cargo hold. Web frames are spaced 12 feet apart, composed of 15-pound plate and 6-inch by 3½-inch by 11.9-pound angles, the depth of the tank forming a belt from keel to keel throughout the cargo space. Between the web frames the frames are composed of a 15-inch and 33-pound channel, 15-pound bilge bracket and 12-inch by 25-pound channel on the top sides, spaced 36-inch centers.

The fore peak framing is composed of 6-inch channels spaced 18-inch centers, and the after end from the cargo to the after peak 6-inch channels spaced 24-inch centers. The floors in the engine room and peaks are made of 15-pound plate, the engine-room floors being stiffened on top with double 3½-inch by 3½-inch by 8½-pound angles.

The center keelson is composed of a 22½-pound plate 60 inches deep and stiffened with angles top and bottom, as well as vertical angles for connecting the floors and keelson together.

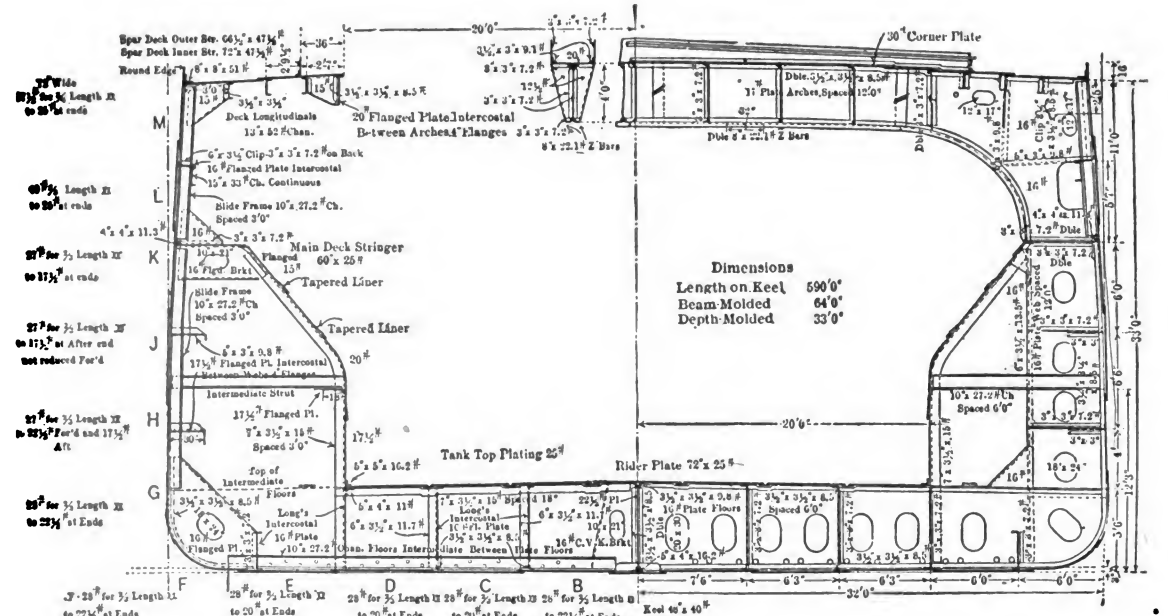


PLATE I.—Midship section of Great Lakes steamer "Col. James M. Schoonmaker."

The keel angles of the "Sheadle" are 5 inches by 4 inches by 14½ pounds top and vertical angles 3½ inches by 3½ inches by 8½ pounds. This center keelson is water-tight from the collision bulkhead to the engine room. There are four longitudinals on each side of the center keelson extending in one piece from the top of the floors to the tank top, composed of 15-pound plate with 3-inch by 3-inch by 7.2-pound angles top and bottom and 5-inch by 3-inch by 9.8-pound vertical stiffening angles.

Between the floors intercostal plates, 15 pounds per square foot and flanged to the shell plating, are fitted. Manholes are punched out and so arranged that the longitudinals retain their strength throughout equal to the unavoidable weakest section.

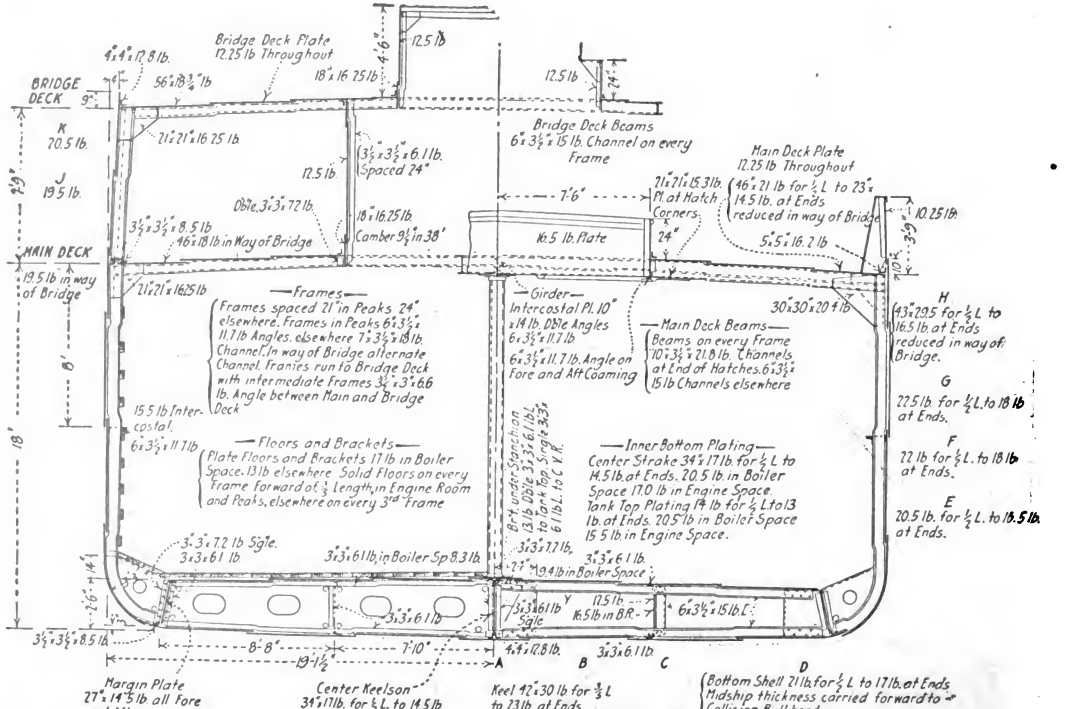


PLATE 2.—Midship section of steamers "Yaqua," "Yuna" and "Inca."

The tank top of the "Sheadle" is composed of 20-pound plating and stiffened with 9-inch by 20-pound channels at the bulbs and 4-inch by 3-inch by 8½-pound angles 18-inch centers between. The water ballast tank runs to main deck line, 5 feet wide at sides. The keel plating is 42 inches long by 37½ pounds per square foot throughout, and is of two thicknesses at the water-tight divisions.

The garboard and main deck strakes are 28 pounds, bottom and side plating 25 pounds, bilge strake 30 pounds, and the sheer strake with strake below 37½ pounds per square foot for two-thirds length of the ship, the sheer strake ¾-inch length.

The spar deck stringer is composed of two plates in width, 37½ pounds per square foot, edge and edge and strapped with continuous plate 36 inches by 40 pounds per square foot.

The stringer angle connecting shell plating and stringer together is composed of angle 6 inches by 6 inches by 28.7 pounds. The spar deck plating between the hatches is 20 pounds per square foot, and 12½ pounds at the ends.

The main deck stringer is composed of 28-pound plate and 3½-inch by 3½-inch by 8½-pound shell angle, and 5-inch by 5-inch by 16.2-pound angle on face, forming top of side tank.

The main deck stringer at ends is reduced to 15 pounds per square foot.

Four other stringers are fitted on the ship's side, one between main and spare deck and two between main deck and tank top, all composed of 15-inch by 33-pound channels on the face of frames and 15-inch intercostal plates flanged to the shell plating. The stringer in line with tank top is composed of plate and angle; between the hatch openings and in line of hatches are girders under the spare deck composed of 12½-inch by 25-pound and 15-inch by 33-pound channels and flanged intercostal plates 15 pounds per square foot between hatches and ship's side.

The spare deck beams between the web frames from the hatch openings to ship's sides are composed of 12-inch by 25-pound channels connected to every frame with bracket plates 15 pounds per square foot.

Main deck beams at ends 12-inch by 25-pound channels, forecastle beams 6-inch by 13.3-pound channels, pantry beams 9-inch by 15-pound channels with fore and afters of the same size.

Stanchions 12-inch by 25-pound channels are fitted in fore peak and engine rooms, after 'tween decks and forecastle 6-inch by 3½-inch by 15-pound channel. There are eight bulkheads, the collision one 24 feet from stem, three bulkheads in hold, coal bunker, boiler room, engine room and stuffing box bulkhead about 9 feet forward of stern post. Collision, forward hold, and stuffing-box bulkhead are 15-pound plate and 6-inch by 3½-inch by 15-pound channels and made water-tight.

The other two hold bulkheads are of 12½-pound and 15-pound plate and channel stiffeners, likewise the engine, boiler and bunker bulkheads, which are water-tight.

Keel and sheer strakes are riveted with 1-inch rivets, and the balance of shell plating ⅞-inch diameter.

The spar deck stringers are riveted with 1-inch rivets for ¾-inch length and balance ⅞-inch, deck plating between stringers double lapped ⅞-inch riveting to the stringers and balance ¾-inch.

Side stringers, deck girders, tank top and all interior riveting ¾-inch diameter.

Snap rivets have their heads and points of the same size, and in no case are the flush rivets under the surface of the plating, but are full and are very nicely laid up around the edges.

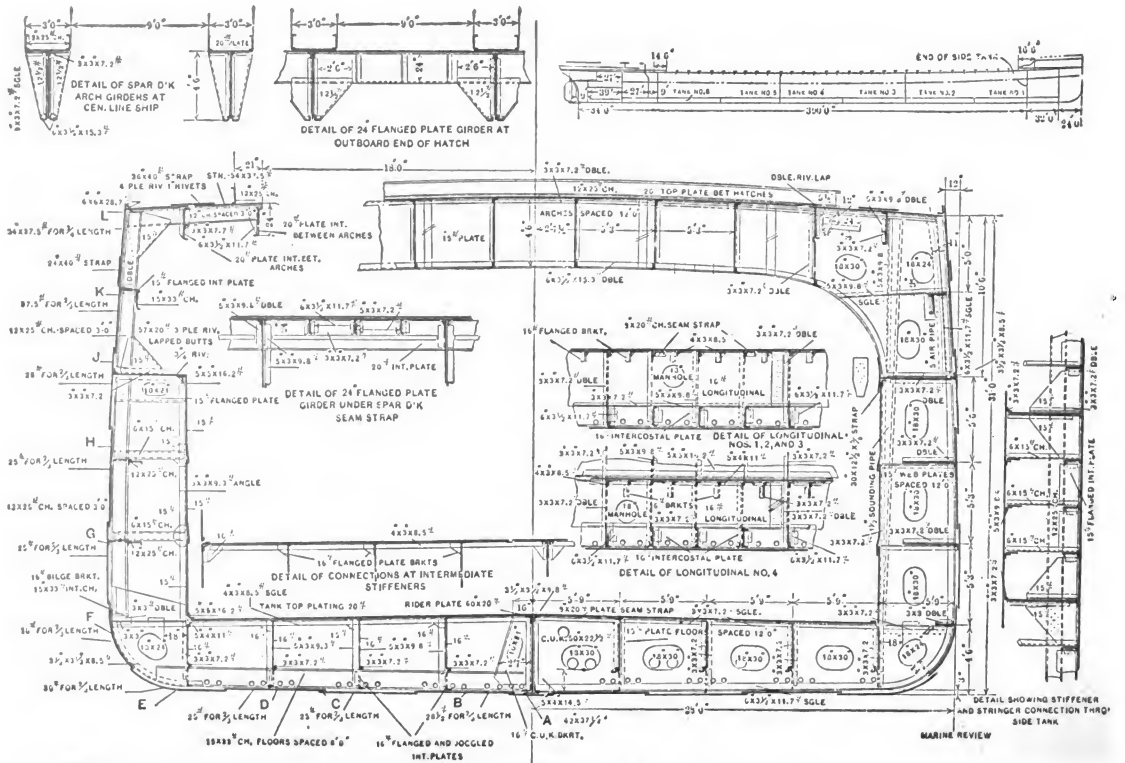


PLATE 3.—Midship section of Great Lakes steamers "J. H. Sheadle" and "Wm. P. Snyder."

TEMPLATES

The side of a ship is not a flat piece of metal, but it bulges from keel to deck and from bow to stern. The beautiful lines of the modern ship have often been commented upon. It is obvious that the shape is due to the curve of the ribs or transverses.

If all the transverses were of corresponding angles it would be a very simple matter to make templates (patterns), but there are hundreds of different complex curves and angles which produce the shape of the ship from bow to stern. This is where the occupation of shipfitting and its branches come in.

Templates as a rule are made in the mold loft, unless it is required to get the shape from the hull or shell on the "ways"; in this case the shipfitter is said to *lift* a template.

The template is to the ship builder what a paper pattern is to a tailor; before the material can be cut the pattern must be accurate.

The wood generally used for templates is spruce, Oregon pine or cedar. These being chosen because of their bending qualities.

Template wood is ¼ inch thick, and runs from 4 inches to 14 inches in width and is of various lengths.

When making the template on the scrieve board, the blue prints are referred to for sizes. These blue prints are not complicated, and can be easily understood with a little study.

After the template is put together in the shape desired, the

marks for rivet holes are accurately spaced off, and small holes are drilled through the wood with a small wood drill, the holes are then circled with blue crayon, and the blue crayon is painted over with orange shellac so that if the template should get wet or dirty, the blue marks would not be erased. *Remember it is very important that the blue crayon circles are put around the proper holes*, because, in constructing the frame of the template, nails have been driven into the wood to hold it in place on the floor, consequently there are many holes. It would be very confusing to the duplicating shop if the holes wanted were not specially marked, so that is the reason for the blue crayon circles.

The transverse number is always marked on all parts to be placed in the hull, so that any position in the hull can be found without delay.

The description,—that is, the position of transverse; shear mark; pitch mark; fore and aft ends; port or starboard; top end; landing, etc., is all marked on the template with black shellac, and it is now ready for the duplicating shop.

Home Practice.—When you have finished a template, damage some portion of it and repair it. Do not fail to put in all marks necessary, so that you will become familiar with markings, etc.

All template lessons should be worked out and practiced until thoroughly learned.

In making templates, if wood is not procurable, cardboard is a very good substitute.

You will need the following tools: claw hammer, large jack knife, hand drill and bits, two-foot rule, chalk line, steel tape, dividers, small hand plane, screw driver, trammel points and try-square. Many shipyards supply the necessary tools.

TEMPLATE MARKING

The template shows the outline, and all rivet holes. The template also shows where the plate is to be sheared, planed or scarphed, and whether or not the rivet holes are to be countersunk.

In Fig. 29 is shown a template of a shell plate. The strip running horizontally through the template has the holes for the longitudinal bored in it. The five strips running up and down are extra pieces to strengthen the template.

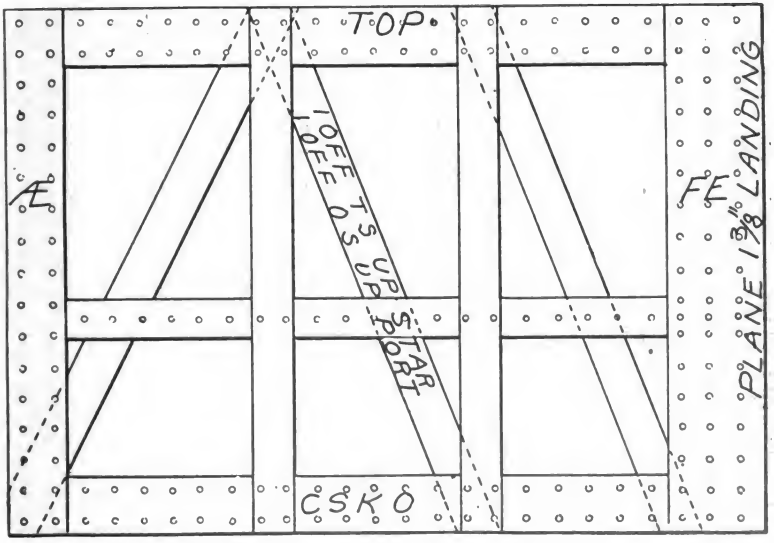


Fig. 29.—Example of marking a template for a shell plate.

The after end (A E), fore end (F E), and top are shown. The plate is to be planed so as to leave a landing or margin of 1⅜ inches from the edge of the plate to the center of the first rivet hole.

The rivet holes are to be countersunk on the other side (C S K O).

All the rivet holes in the plate are to be C S K O, otherwise there would be a line around the holes on the template as shown in Fig. 83; *D C S K* means don't countersink, as shown in Fig. 30.

The marking *1 Off T S Up (this side up) Starboard, 1 Off O S Up (other side up) Port,* means that the face of the template with the marking must be up to transfer the starboard side, but to transfer the port side the template must be turned over, so that the position of the holes, etc., will be reversed.

Fig. 30 is a template of longitudinal 4 between transverses 53 and 57.

S is the shear mark or place where the plate is to be cut; M, drill holes to be transferred to the web of the channel bar; 53 is the transverse number, showing that the

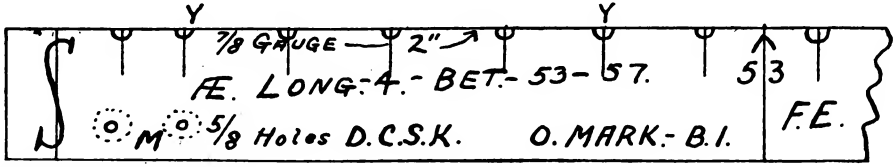


Fig. 30.—Template of a longitudinal.

plate is to be placed on transverse 53 at this point. The order mark B1, shows that the plate is No. 1, and is to be placed in strake B, on the hull. The rivet holes at M, are to be 5/8-inch in diameter, and D C S K (don't countersink). At Y Y are rivet spaces and semi-circles marked in crayon. The rivet holes are to be 7/8-inch in diameter, and gauged 2 inches; these marks to be transferred to the flange of the channel bar. The after end and fore end of the plate are marked.

TERMS & ABBREVIATIONS

USED ON TEMPLATES, PLATES, ETC.

A E.—After end (rear or stern).
A P.—After peak (rear).
B DK.—Boat deck.
Bevel.—Either open or closed from 90°.
B H.—Bulkhead.
C L.—Center line.
Center Punch.—Larger than the prick punch and used to make the impressions made by the prick punch larger and clearer.
C S K.—Counter sink holes.
C S K Over—Turn the object over and C S K.
Don't C S K.—Don't countersink the holes.
Draught Mark.—The stern and stem are marked in feet to show the draught or depth of the vessel.
F DK.—Forecastle deck.
F E.—Forward end (front or bow).
F P.—Fore peak (front).
F or Fr.—Frame.
Gauge.—The distance from the heel of an angle to the center of rivet holes.
H.—Hull
I B.—Inboard; looking from either side toward the center of the ship.
Knuckle.—To bend or flange the plate.
Land or Landing.—The distance from the center of the rivet hole to the edge of plate. For instance, 1⅜-inch landing; the distance from the center of the hole to the edge of the plate will be 1⅜ inch.

Lap.—Two plates with the ends overlapping.

L.—Left.

L B P.—Length between perpendiculars.

L O A.—Length over all.

L or Long.—Longitudinal.

L W L.—Length of load water line.

Molded Depth.—Measured from the top of the keel to the top of the upper deck beam.

M L.—Molded line.

O B.—Outboard; looking from the centerline out toward the sides of ship.

O DK.—Observation deck.

O S.—Other side.

P DK.—Poop deck.

Plane.—For all water-tight or oil-tight work, or when an exceptionally neat job is wanted, the edge of the plate is planed or made smooth. This is done by a large machine called the "planer." When a template is marked plane 1⅜-inch landing, that means that the edge of plate will have to be smoothed down to this distance from the center of the hole or holes.

Plate Lap.—Two plates with the ends overlapping.

P M.—Pitch mark. When a template of a bar is too long to handle, it is cut in two, the ends are extended about three feet where the cut was made, pencil line across the width and put P M on each to indicate the proper position for them to be placed together again.

Plimsoll Mark.—A circle with line running horizontally through the center, painted on the ship near the water line to indicate the limit of load. According to Lloyd's this line must not be below the water line.

Port.—Left hand side looking toward the stem.

R.—Right.

S DK.—Shelter deck.

$.—Shear. For all ordinary work, the plate is cut by a machine, called "shears," which operate in the same manner as a pair of scissors.

S P.—Stern post.

Starboard.—Right hand side looking toward the stem.

T T.—Tank top.

Top.—Looking up from the bottom; sometimes the word "*top*" is written on the template to indicate outboard.

T S.—This side.

U DK.—Upper deck.

W T.—Water-tight.

1 Off T S Up Port, 1 Off O S Up Starboard.—For the port, the face of the template, at which part we are looking with the print on, must be up. Then, to get the starboard plate, the template has to be turned over.

REPAIRING TEMPLATES

We shall take a longitudinal for example. There are two kinds, the straight and the curved edge. When you get a template of the straight edge, to be made over into a new template, the first thing to do is to get a chalk line down on the floor.

How to Lay the Chalk Line.—Your helper holds one end of the line and you hold the other end in your left hand. Hold the chalk (which fits the palm of the hand) in your right hand and draw it along the line. Both you and your helper twist the line around your index finger and press it on the floor with your thumb.

The line must be drawn tight or you will not get a straight line; place it along the center of a board in the floor. "Snap" the line and a straight line is the result.

The template to be made is, say, 6 inches wide. The reason for its being six inches is because the drill holes are sometimes down 5 inches or so from the heel (smooth edge). See M, Fig. 30.

The length is then planed straight on the planer, one edge only. It is then laid down with the smooth edge to the chalk line. Have your old template above the chalk line in position, so you see the length desired. When one length is not as long as the old one, two or more must be joined together, Fig. 31.

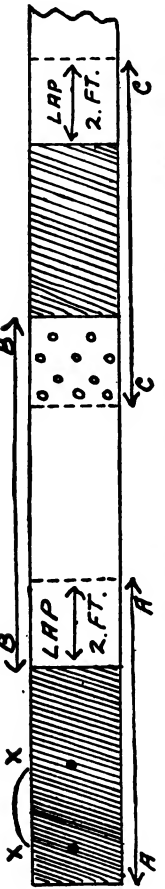


Fig. 31.—Method of lapping boards in template construction. AA indicates length of first board, BB, length of the second board and CC, length of the third board. Note how BB, is placed on AA, and CC. Nails are shown at XX.

The new boards are lapped over one another about two feet between A A, and B B.

Carpet tacks are used to tack the boards in place. Always start at one end and finish at the other, and then you can tack the joined parts or laps together.

For a 6 inch, three rows of tacks 2 inches apart will be sufficient.

If two lengths are too long, the end of one should be cut off with your jack knife.

In doing this grasp the handle firmly in the palm of the hand and then draw gently toward yourself for the first stroke.

Then take four or five heavy strokes over the same mark. Then place your knife at an angle of 45° and one more stroke, which will open the crack more and allow sufficient space to be lifted.

Now place the foot with the edge of the sole at the cut on the part that is wanted and snap off by lifting the surplus, and trim the edges of the cut.

Cleats are placed at the middle and ends of the template to strengthen it. The best cleats to use are six inches wide.

Place the cleats so that the grain of the cleats will not run the same way as the grain of the template.

Cut off any surplus over the width. The old template is now ready to be transferred.

Place the old template directly over the new one, with the straight edges together. Start at one end and nail down with six-penny nails (Fig. 31, X X). Now drive in nails until they catch the floor; they are placed only temporarily and must be pulled out later with the claw hammer.

Drive nails about three feet apart and especially where there are any rivet holes, because if edges are not even, the drill holes on the new template will be shorter or longer from the heel or smooth edge. *This is very important.*

The holes are then drilled with the hand drill just enough to go through. **It is important to hold your drill perfectly vertical.** The space marks are then copied on the edge. Use the tri-square, and square off the marks from the old to the new edge (Fig. 30, Y Y).

When all marks have been transferred the old template is taken off and placed in front of the new one. Set your tri-square on the template and draw your lines, which you have marked off on the smooth edge, half across the width. Circle all holes with crayon as at Fig. 30, M. Be certain that you transfer mark for mark in the proper place, also description. When shellaced, it is finished.

To Repair a Curved Template.—Place the old template on the floor. If, for instance, it be 8 inches in width, you will need

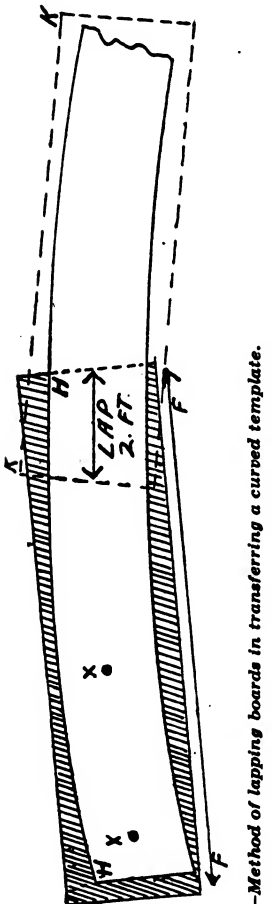


Fig. 32.—Method of lapping boards in transferring a curved template.

at least 10-inch new boards. The new boards need not be planed. Place the first length under the old template, starting from one end (Fig. 32).

When in position the center of the new board must protrude at least ¼ inch out from the old template. Of course, the ends will be out much further; on account of the curve, one end should not be out more than the other end. Nail down at the end, and in the middle at X X. Take a pencil and run it along the edge (curve) of the old template H H.

If it require more than one length, it will be necessary to join two or more together, by overlapping.

Don't disturb the first operation, but proceed to place your second in a similar position as the first, but to overlap the first with the second (K K) about two feet.

Next drive in a nail, temporarily, through the overlap and in the middle of the second board, and draw your pencil line as before; be sure to draw the entire length of boards over the overlap.

If it be necessary to have a third length, place it under the second to lap over about two feet.

When the required length is obtained, and you have marked your entire length, pencil mark the ends of each board, so you will know in which position to return them. Withdraw all the nails with claw hammer and lift old template to one side.

Starting with your left board, number the boards No. 1 for the first, No. 2 for the second, and so on. You now have the boards ready for the band saw. Keep about $\frac{1}{8}$ inch of wood outside the pencil line, when you have them finished. Place your old template on the floor, and on top place your new boards, starting from the left No. 1, arrange your boards exactly as you had them underneath by driving temporarily a nail in the end, the middle and overlaps. Always start from one end, and work to the other. When all is in place, smooth and shave with hand plane, so that both edges of the old and new templates are even.

Next tack all the overlaps with tacks, about three rows will be sufficient to hold them securely.

Now withdraw nails. Just lift to one side, in front of you. Clear off the old one, then place cleats or braces on the ends and between the overlaps.

There should be a cleat every three or four feet apart. Cleats in every case should be six inches in width, unless the width be narrower than six inches, then you will use the same width. Cleats should not have the grain run the same as the template. Always have your cleats even to the heel, or smooth edge; if not, trim off with your jack knife.

Next, get your cleating iron (a flat piece of steel or iron), turn your new template over, with the heads of the tacks down,

put your cleating iron underneath and hammer the points of the tacks down flat.

Next operation is to place your old template on the new; be sure the edges are even, start from one end, and nail down again; special care must be taken at that part where there are any drill holes to have edges even. Transfer hole for hole and mark for mark. Shellac your holes after crayon. Description of your template marked in black shellac. Always mark F E, (fore end), A E, (after end or rear), shear marks, pitch marks, if any, transverse marks, order marks, description of a shelter, upper, etc., not forgetting your bevel marks, if any, size of rivet holes, gauge number of template and between what longitudinals if a curved template what degrees, open or closed bevel, and then your new template is finished.

If the old template is not desired any more, it should be broken up. But it is the rule in many places to keep the template, if in fairly good condition, by marking across the face the word record, and it is placed in a special place, in case it be needed for future reference.

Always look over your work, after each piece is finished. Remember, *in no case must three thicknesses of wood come together.*

That is, if you had a cleat underneath the template and one on top. The bottom, top and the template, itself, would make 3 thicknesses.

The best plan is, always when joining or overlapping the boards to put the second on the first and the third underneath the second, as in Fig. 31. By so doing you have the ends of the middle board resting on the first and third.

When you get that position it is very simple to place your cleats. On the first board, starting from the left, the cleats go

on the top, because then they will be the same height as the overlap No. 2 over No. 1. The cleats on the middle boards go underneath, the third board on top, and so on.

Always choose new template boards free from knots and cracks. Test each by slightly bending.

To Repair the Template of a Side Shell.—Place the old template down on the floor. Build the new frame exactly on top, keeping edges even, when finished. Reverse the frames, place the old template on top. Drill all holes and put in markings word for word. The old template is taken off and finished as usual.

To Mark Template Shell.—F E, or A E—Upper D K, number. Get the above together, the rest can be marked any place convenient, except that plane marks, C S K, etc., must be in the proper places. Because on some, the sides have different plane dimensions. Not all holes are C S K, and in that case the mark must be at that spot.

To Repair Curved Template, Damaged in the Center.—Nail temporarily both ends of the template, also about three feet from ends. Place new board underneath, to get the curve H H, as shown in Fig. 32. Saw off at the band saw. Place on top of old template and plane even with the old template. Be careful and don't plane any off the old template. Place underneath and transfer marks, not forgetting to nail.

You may now cut away the damaged part, allowing for overlaps.

Tack and mark.

The main feature is not to lose the original curve, or to make it longer or shorter.

To Repair Straight Template Partly Damaged.—Get new boards to the chalk line, if more than one by overlapping until you have sufficient length for damaged part, and about two feet extra for each overlap.

Tack securely to the floor and place the damaged part of the old template to be transferred, over the new. Nail together, having the old template in its entire length to the chalk line.

Transfer marks and holes.

Next cut old template about two feet over the end of the new board. Tack the overlap and mark the new portions.

Sometimes it is necessary to remark the old markings on account of being erased or being dirty, through handling.

Sometimes the new board must be placed on top of the old one at the overlap on account of a cleat or another overlap near. This can be accomplished by springing your boards to one side carefully.

Never have two overlaps near one another, as it will make the template too stiff.

LOFT WORK

Box Templates.—Where a number of clips are to be laid off the same template, a box template, is generally made. This is a template made like the angle bar; in fact, is made to fit over the angle. The inside of the box template fits over the outside of the bar. As this template has to be made of heavier wood than ordinary template wood, it would be impractical to drill a $\frac{5}{32}$-inch hole into it, as the prick punch would split the wood; consequently, holes of about $\frac{1}{2}$ inch in diameter are bored in the template for the rivet holes.

Therefore, in duplicating a template of this particular kind, $\frac{1}{2}$ inch duplicating punch would be necessary. Care must be taken to allow for the thickness of the wood, when the $\frac{1}{2}$ inch holes are bored in the template. The gauge must be measured in the inside or bosom of the template.

If, for instance, the gauge be 2 inches from the heel, and measurements were taken from the outside. When the template is applied, and the holes punched, the gauge from the heel on the bar would be less than 2 inches, the thickness of the wood making the difference.

The ends of the box templates are the shear marks, so at each end of the template draw a line on the bar corresponding to the end of the template.

To Develop a Longitudinal from the Scrieve Board.—For example, we will take longitudinal No. 3, between the frames for transverses No. 75 and No. 85.

The first thing is to find the size of the bar of the longitudinal, see forebody shell blue print, Fig. 28. As the blue print gives the dimensions, we will say that the longitudinal is a channel bar, and the size is 7 inches by .4 inch by 3.5 inches by .45 inch.

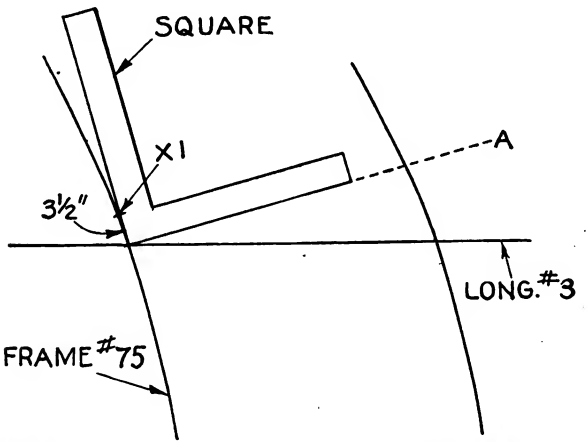


Fig. 33.—Method of picking up a longitudinal line from the scrieve board.

Therefore, the web is 7 inches wide and the flange is 3½ inches wide.

Procure a batten and a square. The intersecting point of the frame No. 75 and longitudinal No. 3 is the starting point. Always start from the after end. The bar being 3½ inches (flange to shell), measure the same, 3½ inches up on the frame No. 75

from longitudinal No. 3, see X1, Fig. 33. Set the square along the frame No. 75. The corner of the square must rest in the corner

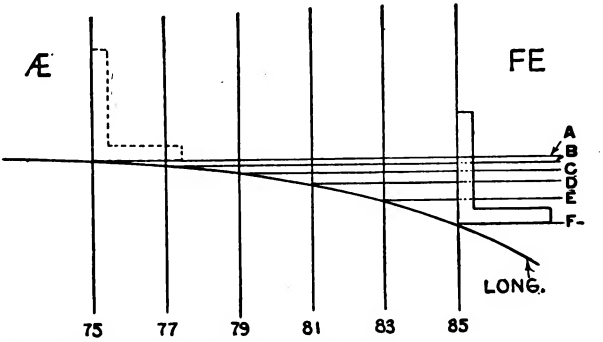


Fig. 34.—How to square off lines from longitudinal.

of the frame and longitudinal, and side of square on point X1; mark line on scrieve board, line A, Fig. 33. The above must be applied to all frames, up to and including frame No. 85, see Fig. 34.

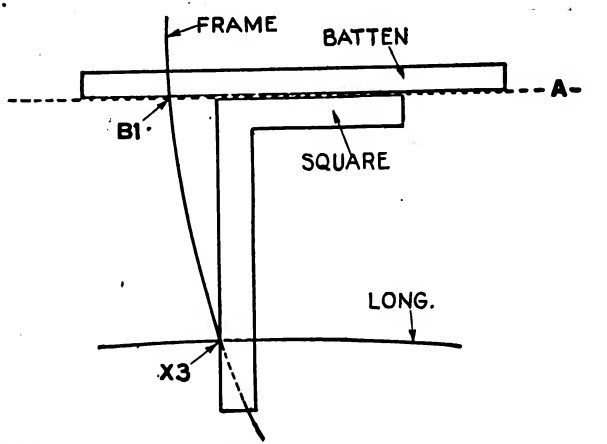


Fig. 35.—How to square on to batten from longitudinal.

Next, lay the batten along the line A, which you squared off from the first frame No. 75, so as to pick up the points on the batten. The point where the batten crosses frame No. 75 and longitudinal No. 3, mark on the batten, see X1, Fig. 33. Be sure to mark that point frame No. 75, so that you will not be confused later. That is your starting point. Don't move the batten, place the square flush against the batten, to pick up the next frame, No. 77; see Fig. 35.

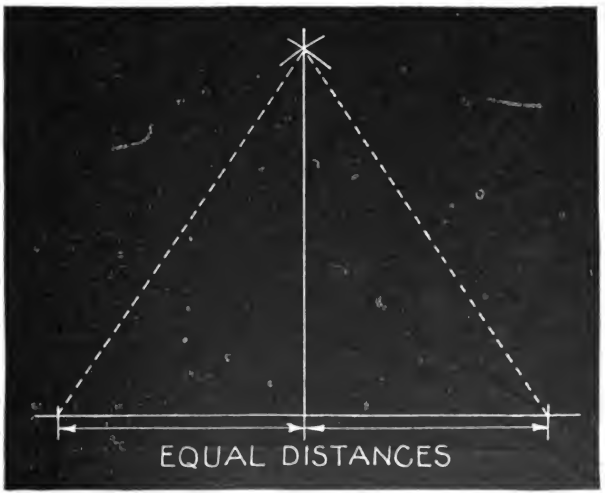


Fig. 36.—How to erect a perpendicular.

The intersecting point of frame No. 77 and longitudinal No. 3, when even with the edge of the square, mark at that point on batten, the frame line No. 77, see B1. Next, move the batten down even to the next dotted line, see B, Fig. 34. The batten, when in this position, must have point B1 exactly at X3, see Fig. 35.

Square off the next frame same as the previous one. T
method applies to the rest of the frames.

When finished, your lines can be laid down on the flo
Snap chalk line on the floor, and have this line about two f
longer than necessary, so that when the template is laid dow
the ends will not be covered up, and obstruct your view. T
line you just put down is known as the base line, as shown
Fig. 37. Next, starting from your left, erect a perpendicul
line, Fig. 36; this line is known as frame No. 75.

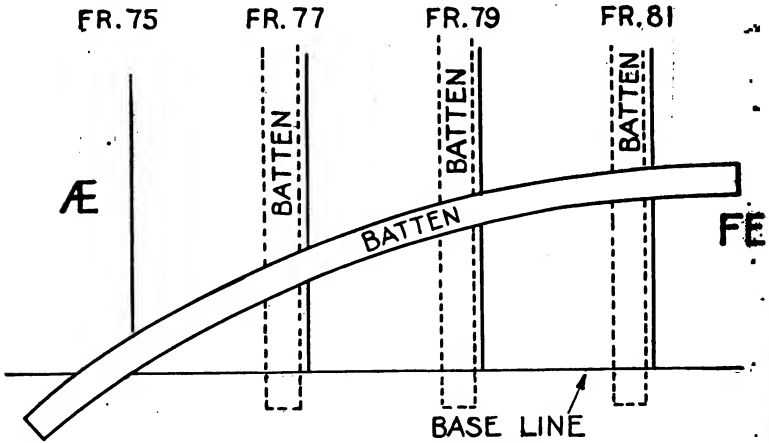


Fig. 37.—Obtaining the high points of curve of longitudinal.

The blue print giving the distance between frames, we will say, ten feet; so measure on the base line from the first perpendicular, ten feet, and erect another line, which will be known as frame No. 77. If the distance is 11 feet between frame No. 77 and No. 79, measure off that distance from your last point, frame

Fig. 38.—Bending floor.

No. 77, and so on, until you have all the desired frames, see Fig. 39.

Place your batten along perpendicular or frame No. 77, as frame No. 75 and the base line, is the starting point of the curve, and have the point No. 75 that is marked on the batten, exactly on base line. Now, transfer mark No. 77 on batten to line on frame on floor.

Move batten to the next perpendicular, or frame line No. 79; have point 75 even with the base line and mark off on frame line No. 79, point No. 79 from the batten, see Fig. 37. This method is used for the rest of the frames. You now have the high points of the curve of the longitudinal.

To get the natural curve, bend the batten from the intersecting point on the base line on frame No. 75 to the points marked off, see Fig. 37. The batten is held in position with long pointed steel pins. It is necessary to move a pin slightly, so as to allow the batten to take its natural curve; as this is very important, care must be taken that no bends occur.

The template wood is now ready to be laid down. As the web of the longitudinal is 7 inches and being curved, it will be necessary to procure template wood, about 10 inches in width. Place your wood as in Fig. 39 and tack down at ends and at laps.

Get a small block of wood a little wider than the distance from the curve of batten to the edge of template (the middle part is further from the batten than end), see A, Fig. 39. Place your pencil against the wooden block, and draw both carefully along the batten. In so doing, you will transfer the curve of the batten to the template wood.

Before removing, be sure to mark the ends of each piece where they intersect, so you will know in what position to return them.

It is a good plan to number each board, beginning from the left; for instance, No. 1, 2, etc.

Saw off at the band saw, along the pencil line and return them to the batten, as in the previous position. This time nail or tack the laps of template permanently, and remove batten without disturbing template. Plane the edge smooth, as the edge will be rough from the band saw.

By standing at the end of template, you can see if any bumps or depressions be present, which must be rounded out. With

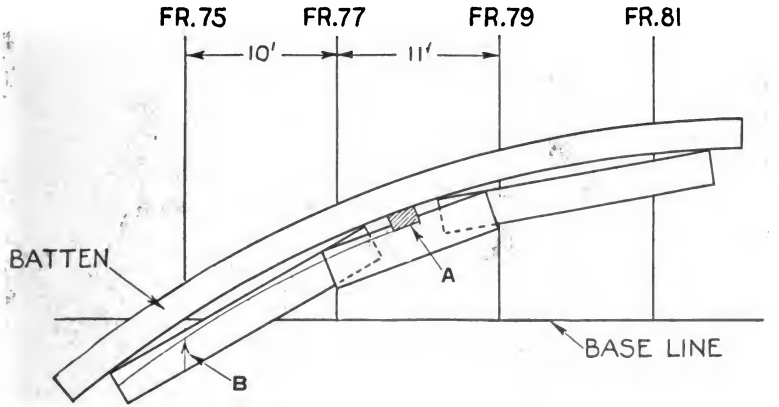


Fig. 39.—Method of placing template wood against a curved batten.

a ruler or straight edge, continue the frame lines to the molded lines. The edge or curved part is known as the heel; a fraction from the edge or heel of template, place an arrow point on each frame, see B, Fig. 39, other marks will be placed on template, but it will be readily observed which is the frame. The template is now ready for shear marks, rivet holes, etc. As a rule, blue prints have the after end to the left, so it is best policy

for the beginner to start at the left. It is an easier way, and less liable to mistakes.

You must get plan or plans of each transverse or frame, that you are doing. First, to get the size of clip that is attached from longitudinal to frame. Second, to get the thickness of the plate of each transverse. Supposing that the heel on frame No. 75 is on the left, therefore, being on the end, it may be a bracket or a long clip—we will do that last. Take the next frame, No. 77: The heel, we will say, is on the left and the thickness of the

Fig. 40.—Training gang in bolting by the Emergency Fleet Corporation.—*Courtesy of the General Electric Co.*

plate of the transverse is 7/16-inch, to left of frame line draw a line, which will be parallel to frame No. 77. That shows the thickness of plate of frame or transverse.

Being a two hole clip and 3½-inch bar, measure out to the left 2 inches from thickness of plate. Being a 7-inch bar, measure down from the heel, 2 inches for the first hole, and 3 inches more

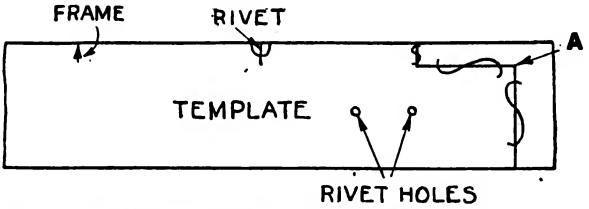


Fig. 41.—Template marked for shearing to allow angle bar to pass through.

for the second hole. Frame No. 79, the heel being on the right, measure thickness of plate and also clip to the right.

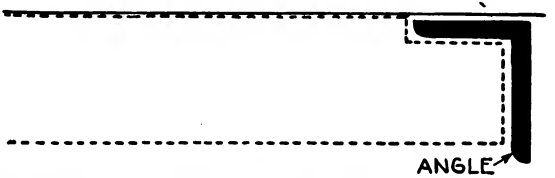


Fig. 42.—Showing bar sheared with angle bar in place.

The next operation is to put in the shear mark. About ¼-inch is the least allowance for space between the bulkhead and the end of the bar. Care must be taken to have the shear mark the proper shape, on account of a flange of a bar being in the way. In that case the shear mark must be cut as shown at A, Fig. 41. At bulkheads, holes must be placed for brackets for a 7-inch bar; measure down 5 inches from the heel of the template.

Draw a line which will be parallel to the heel 18 inches or so from the shear mark. This line is only temporary, for when you space your holes, one will not be nearer or further than 5 inches from the heel. Measure out on the line 1¼ inches from shear mark for the first hole, never less, on account of rivet head.

As blue print shows rivet spacing and size, we will say, 3½ inches from center to center of holes, and 6 hole bracket. Measure off on line 3½ inches from first hole, until you have the total six. These holes are drilled in the template and are known as web holes.

To get the shell holes, which are marked off on the heel of template with pencil, it is necessary to get the shell templates; the number of the plate is given in the blue print, the postion can easily be found by following the transverse numbers.

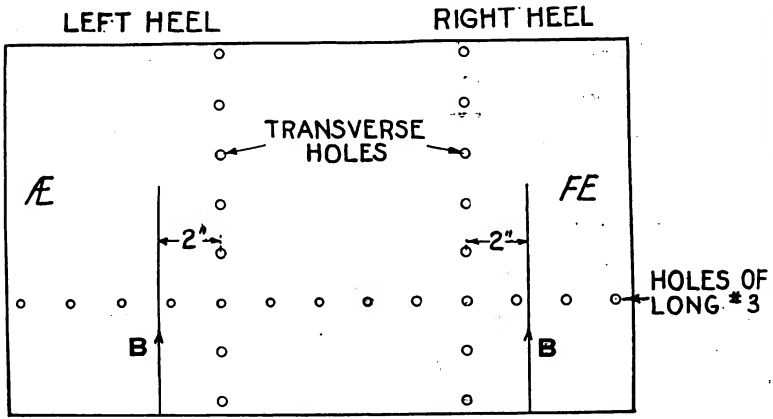


Fig. 43.—Showing how to find the heel on molded line of transverse.

Place the bar template with after end corresponding with the after end of the plate template. Get the line of holes of the first frame, No. 75, of the plate template, and with straight edge or ruler, place over the center of holes, and draw a line where the holes of longitudinal No. 3 crosses, see Fig. 43. Sometimes, the holes of the transverse are not exactly even or straight, then the majority of holes must be taken.

Now, if the heel of the transverse No. be on the left, and the bar be 3½ inches, measure to the left or after end, 2 inches, and draw a line, which will be parallel to the line of holes. This line is known as the heel or molded line. This method must be used for the other transverses on the plate template, care being taken to see if the heel be right or left. You now have the molded lines of the frames on the plate template, and when the molded lines of the bar template are placed together, they should meet

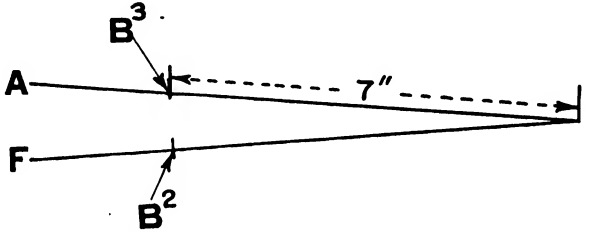


Fig. 44.—How to obtain the twist of a longitudinal.

If the bar were straight, the holes could be transferred. Because of its being a curved longitudinal, and the holes on the plate straight, it is necessary to get a batten and nail down just below the holes in the plate of the longitudinal No. 3. Square off from center of holes on to batten, not forgetting the molded lines.

Remove batten and nail it along the edge and curve of bar template, so that you can transfer the marks. Get the heel of transverse No. 75 on batten, exactly on heel of transverse No. 75 on template, and the rest of the transverse points should meet.

To get the twist of the bar, if any, extend the lines A and F until they meet, see Fig. 44. Then, measure back from

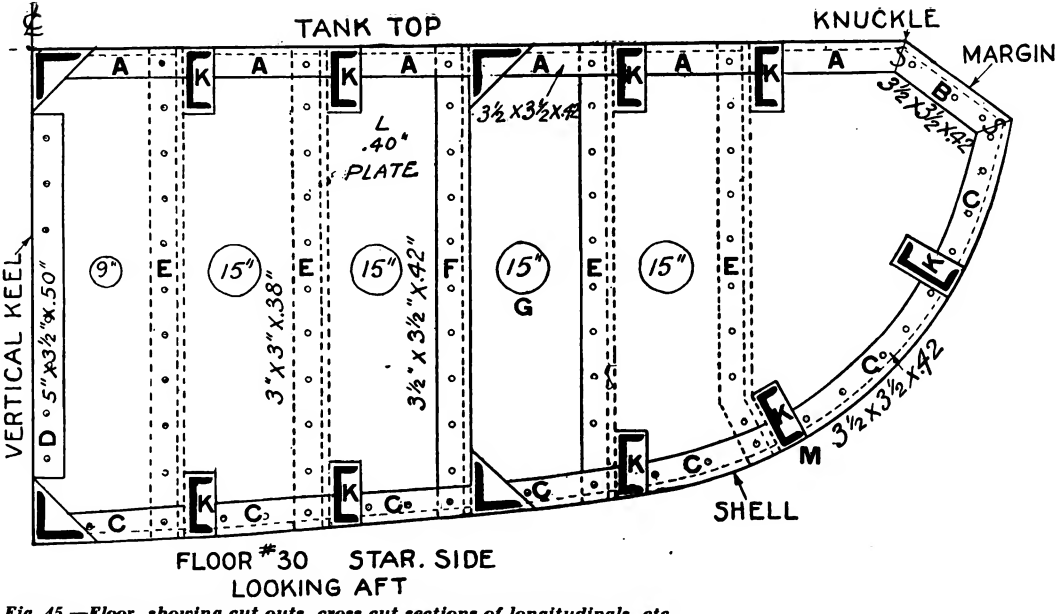


Fig. 45.—Floor, showing cut outs, cross cut sections of longitudinals, etc.

the point where the two lines meet, seven inches. The web of the bar in this lesson is 7 inches. The distance from B2 to B3 is the amount of twist in the bar, see Fig. 44. When properly marked with description, etc., the template is finished.

Developing an Ordinary Non Water-tight Floor from the Scrieve Board.—We are going to take floor No. 30 for our lesson, and first of all, we will study the floor from the blue print. The floor is bounded by the tank top, tank margin, shell and vertical keel, see Fig. 45.

A—Tank top clips, 3½ by 3½ by .42 inch angle.

B—Tank top margin clip, 3½ by 3½ by .42 inch angle.

C—Shell clips, 3½ by 3½ by .42 inch angle.

D—Vertical keel clip, 5 by 3½ by .50 inch angle.

E—Floor to longitudinal clip, 3 by 3 by .38 inch angle.

F—Floor to intercostal girder clip, 3½ by 3½ by .42 inch angle.

G—Manholes, 15 inch diameter.

H—Vertical keel to tank top bar, 3½ by 3½ by .50 inch angle.

I—Vertical keel to shell bar, 5 by 5 by .50 inch angle.

K—Cut outs to let tank top longitudinal and shell longitudinal run through.

The bars that connect floor to tank top are called floor clips to tank top, and are made of a 3½ by 3½ by .42 inch angle. The reason for calling these bars, clips, is that they are made in one piece, and after the floor is all assembled, the burner burns them off, so that they correspond with slot in floor plate which lets the longitudinal run through. They extend from the vertical keel to the margin bar. The margin clip is 3½ by 3½ by. 42 inch angle, connecting the floor plate with the tank margin plate.

In some cases, the floor to tank top bar is knuckled to make this clip; but the better practice is to shear top clips off at the knuckle and make the margin clip separate.

The shell clip is 3½ inches by 3½ inches by .42 inch angle, connecting the floor plate to the shell. The vertical keel clip is

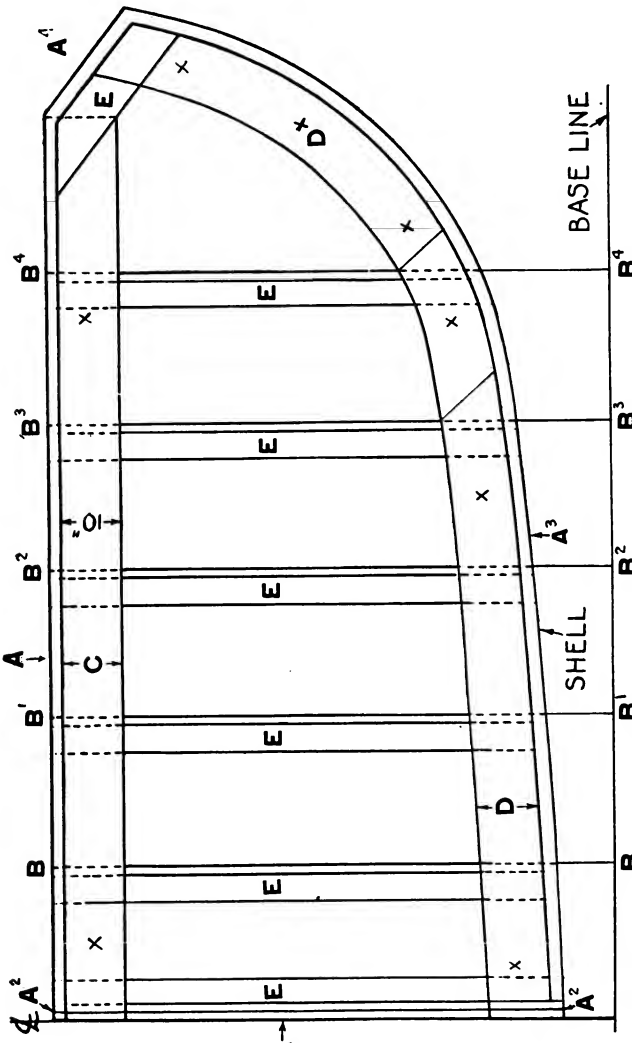


Fig. 46.—Procuring the shape of a floor from the sctieve board.

5 inches by 3½ inches by .42 inch angle, connecting the floorplate to the vertical plate. The 3½-inch flange is on the floor plate, and the 5-inch flange, on the vertical keel plates. The bars, connecting the floor plates with the longitudinals, are 3

inches by 3 inches by .38 inch angle. On an ordinary floor, these clips are riveted firmly to the floor plate, and connected with a longitudinal by two rivets, according to the size of the longitudinal. F is 3½ inches by 3½ inches by .42 inch angle connecting the floor plate with the intercostal girder plate, see Fig. 45. G shows 15-inch manholes that are cut out in the floor, so that a man can crawl through from one floor to another. L, is floor plate itself, and is made of .40 inch plate.

After studying the drawing, we are able to proceed on the scrieve board and make the templates. First, we will find the lines on the floor, see Fig. 46. The center line is marked A. The tank top (T T), is marked A^1. The margin is marked A^4. The shell is marked A^3.

Now, with a piece of yellow crayon or soap stone go over these lines on the scrieve board, so that they can easily be distinguished from the rest of the lines. These are the only lines that are marked in on the scrieve board, that we will use. Find the thickness of the vertical keel plate at Floor No. 30. In this case it is ½ inch. As the center line of the ship is in the center of this plate, we will have to take half this thickness, which is ¼ inch, and measure over from the center line on the board, ¼ inch, and snap line A^2, A^2, Fig. 46. This is the line for the heel of the floor to vertical keel clip.

On the tank top drawing, find the distance from the center line of the tank top longitudinals and girder. Mark these distances off on the tank top molded line, and do the same on the base line. Snap lines between these points B B, B^1 B^1, B^3 B^3, B^4 B^4; these are the lines for the heel of the floor clips to the longitudinals and girder.

Now, find the size of the tank top longitudinals, and we will say they are 8 inches by .45 inches by 3½ inches by .38 inch; then, procure a piece of 10-inch template wood. Lay it about ¼ inch inside the tank top molded line, and hold it in place with six-penny nails, marked X X. The reason for the 10-inch template wood is that the cut outs for the longitudinals have to be marked on it. At the bilge, the wood might have to be wider, in order to mark the curve, see D, Fig. 46.; holding it in place with nails X X, lay pieces of 4-inch template wood at the vertical keel, longitudinals, girder, margin. These are marked E E, etc.

At molded lines B^3 B^3 and B^4 B^4, it will be noted, that the shell longitudinals are on the bilge of the ship. They do not sit parallel with the others, but at an angle, see M, Fig. 45. This angle may be found by measuring 3½ inches from the shell longitudinal molded line, and placing the square on the line, draw line to meet the molded line B^3 B^3. This is the line of the web of the shell longitudinal. Do the same at B^4 B^4, and nail a piece of template wood from this line. Now, tack these pieces of wood firmly together and we have the form of the floor plate.

Now, procure some 4-inch template wood and plane it to a straight edge. Lay one piece of the 4-inch wood with its planed edge on the molded line of the tank top, see C, Fig. 47. Do the same with tank top margin, vertical keel, longitudinal, and the girder molded lines, see E 1, 2, 3, 4 and 5, Fig. 47.

Take a piece of template wood, not less than 4 inches in width, and place it to the shell molded line, see D, Fig. 47.

In actual work, these pieces would be placed over the form of the floor plate, Fig. 46, and the reason for keeping the template wood ¼ inch away from the molded lines, was not to obscure these lines, and to make the work easy to understand.

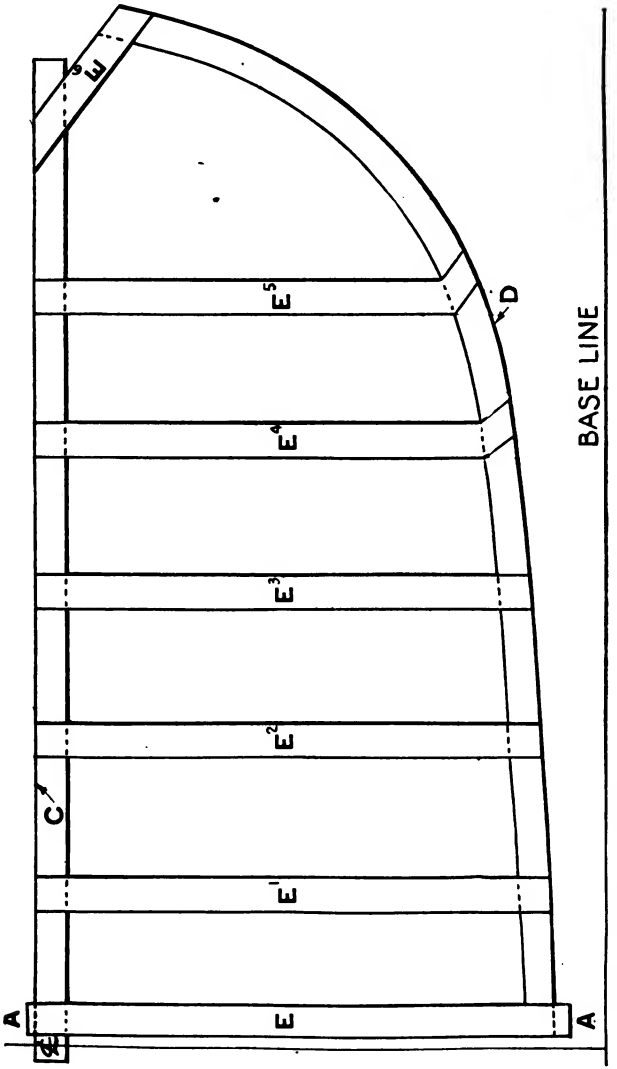


Fig. 47.—Template of a floor.

We now have the mold for our floor plate, and the connections to it. Now space in the holes, beginning with the floors to the tank top clip. Find whether the vertical keel bar to tank top is double (on both sides of vertical plate), or single, and its size. In this case it is on the starboard side, single, 3½ inches by 3½ inches by .50 inch angle. Draw a line on the template, see C, Fig. 47, extending over the center line, measure over from this line ¾ of an inch and draw a line. This is port side shear of the bar. Draw another line 4 inches from the center line. This is the starboard shear of the bar.

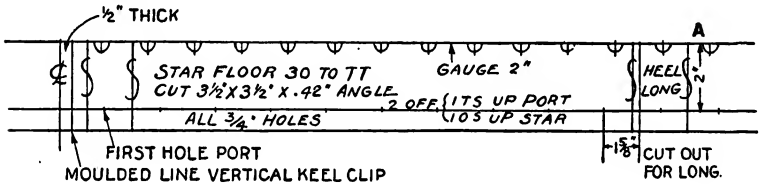


Fig. 48.—Template of a bar, with two shears.

At each place where a longitudinal passes through the floor, the bar will have to be cut, allow about ¼ inch all around the longitudinal for clearance. That will make a slot 4 inches wide by 8¼ inches long. Mark the shears on the clip to correspond to those cut outs. The O B (outboard), shear is at the knuckle point. As this is a 3½-inch by 3½-inch angle, our gauge for the rivet holes will be 2 inches, so draw a line 2 inches from the heel, the full length of the template, see A, Fig. 48.

Now, measure 2 inches from the molded line of the vertical keel clip and mark this on the gauged line; this is the first rivet hole in the clip. This hole is only on the port side. Now, measure 3½ inches from this hole and mark another hole.

This is the first hole in the starboard bar. It is also in the port bar. Then measure over 1⅝ inches from the tank top longitudinal, and mark for another hole. This is also in the floor clip to longitudinal bar. Spacing the remaining distance for the first hole for the starboard side and the last hole we have measured, this completes the clip between the first longitudinal and the center line.

Proceed with the rest of the bar in the same manner until the knuckle is reached.

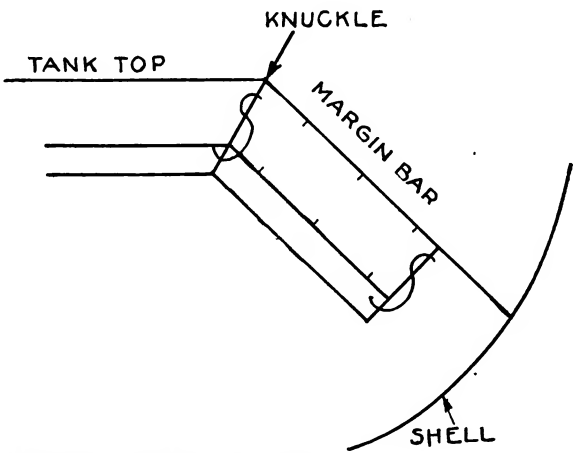


Fig. 49.—Template of a bar showing knuckle.

Shear that bar on a bevel of about 45°. That will permit of the fitting in of the margin clip, see Fig. 49. Gauge these holes from the margin molded line, the vertical keel clip, shear 4 inches from the tank top molded line, shown at A, Fig. 51, and 5½ inches from the shell line as at B. Space the holes the same as the other clips. (Note, this clip is 5 inches by 3½ inches.) We are applying the 3½-inch flange to the floor, and

the 5-inch flange to the vertical keel. The flange to the vertical keel must be water tight.

The best policy would be to have the vertical keel clips made with vertical keel plates, see Fig. 52. Then, we would have the

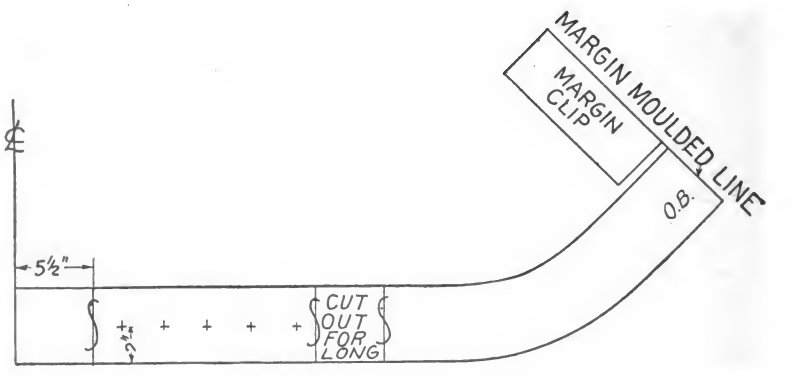


Fig. 50.—Template of a bar (shell).

same as in the tank top clip. Beginning in the holes, about 1½ inches from the shears, the margin clip will shear off at the shell bar, see Fig. 50. The shell bar is a clip made the same as a tank top clip.

Now that the vertical keel bars to flat keel are 5 inches by 5 inches, double, that is, there is a 5-inch by 5-inch bar on both sides, port and starboard, so that the shell bar will shear 5½ inches from the center line, for the inboard shear and for the outboard shear will be ¼ inch. Now space the holes in the floor template and pick them up on the clip templates as gauged holes. Now that we have all our holes spaced in, we will proceed to

drill these holes through the clip templates, and into the floor plate template.

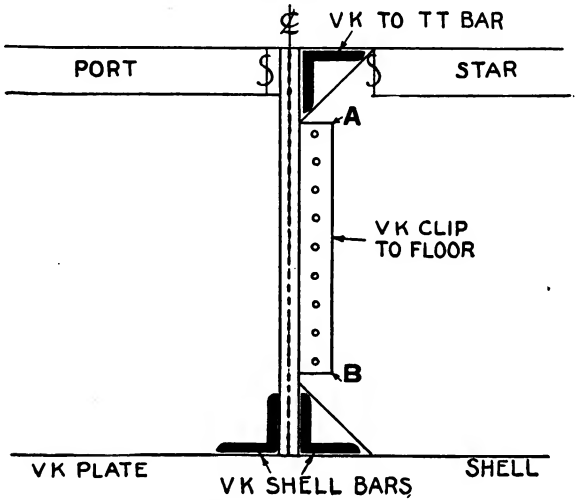


Fig. 51.—Section of double bottom.

After drilling the holes, we will take the tank top clip template, and be sure the center line mark is on this template, and pick up the holes in the tank top plates.

Procure the tank top templates that frame No. 30 is in and

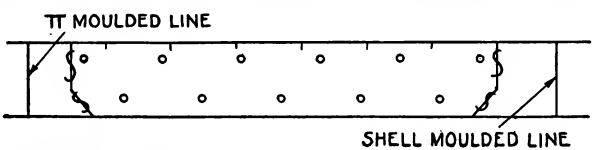


Fig. 52.—Template of a clip.

place them on the floor, as they would go on the ship. Then apply the center line of the clip templates to the center line of the center plate of the tank top, as shown in Fig. 53, and nail the templates

down as shown. Then with a small square, square off these holes that are in the tank top plates on to the floor clip template. Care must be taken in doing this to see that the holes are squared off exactly in the center, and that the templates are not moved.

After the holes are picked up, the templates are ready for mark-

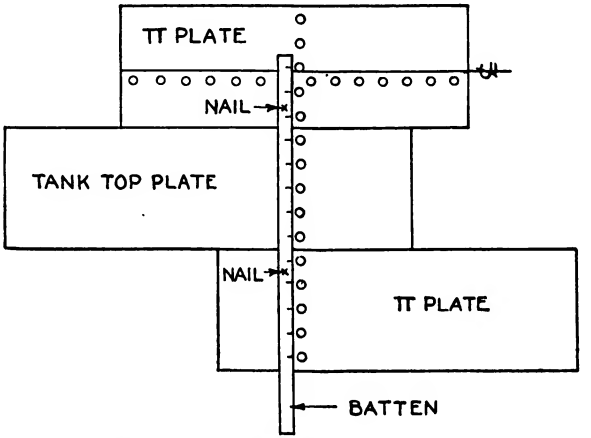


Fig. 53.—Method of picking holes from templates of tank top plates onto batten.

ing, see Fig. 54, with all necessary descriptions, not forgetting 1 *Off—T S Up Starboard*, 1 *Off—O S Up Port*. The bar is on

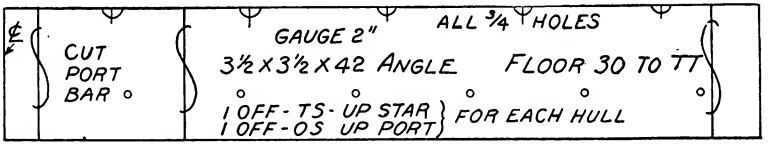


Fig. 54.—Template of an angle with two sheers, port and starboard.

the forward side of the floor plate, and we lay down the port side; therefore, when the template is laid off on the bar, and applying this side up, the flange will be down.

Lifting an Intercostal from the Scrieve Board.—For our lesson, we shall take an intercostal where there is a rise in tank top and shell. This will come either fore or aft, but in this case, we shall take the one between floors No. 41½ and No. 42.

Locate the frame lines No. 41½ and No. 42 on the scrieve board, also the tank top lines No. 41½ and No. 42. Now, find

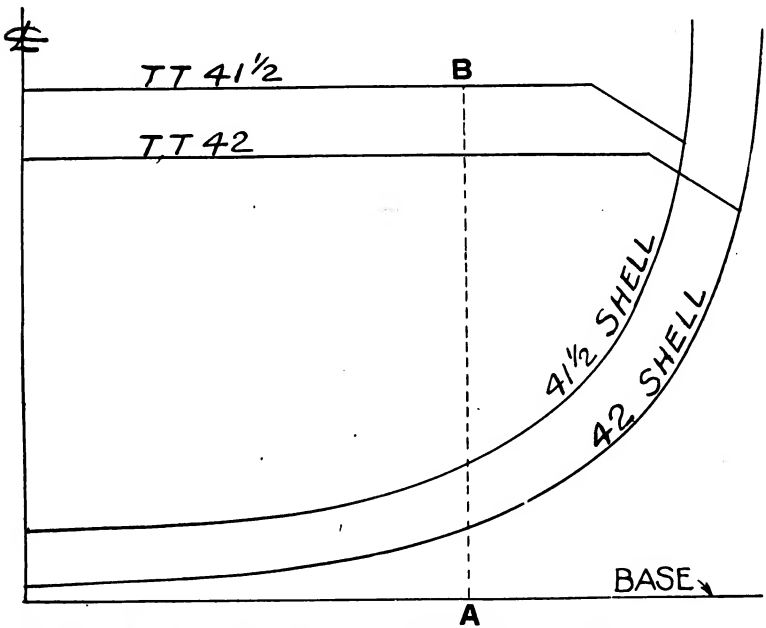


Fig. 55.—Method of picking up lines from scrieve board for an intercostal.

the distance from the center line of the intercostal girder.

This may be taken off from the tank top template or drawing and mark this off on the tank top line No. 42, as at B, Fig. 55.

Then, drop the perpendicular A B, to the base. Then, lay a batten on this line, having it extend a little beyond the base and tank top line No. 42. Then, pick up the base line, shell line No. 41½ and No. 42; tank top line No. 41½ and No. 42. Now, we have all the lines that we shall need from the scrieve board.

Next, find the spacing between floors, and we shall say it is 5 feet, and snap a line A B, Fig. 56, on the floor about 5 feet long.

Then, at the point A, erect a perpendicular A C. Have this line a little longer than the height from the base to the tank top line No. 42.

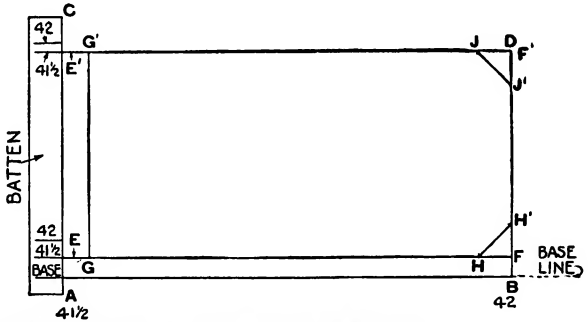


Fig. 56.—Lines of an intercostal plate from scrieve board.

Erect a perpendicular B D. Then, we will mark the line A C, No. 41½ and the line B D, No. 42. And the line A B, will be our base line.

Now, lay the batten down on the line A C, having the base line of it corresponding with the base line A B. Mark off on the line A C. The shell line at No. 41½ which will be the point E and the tank top line E^1.

Now, move the batten to the line B D and apply it the same as at A C, and mark off the shell point F and the tank top F^1. Now, connect the points E F and E^1, F^1, with straight lines.

Assuming that our floor clips to shell and floor clips to tank top are on the after side of the floor, which would ordinarily be the case, we shall have to allow the thickness of the floor plate, No. 41½, and this will be about ⅜ of an inch thick, so measure over from the lines B and C, ⅜-inch, and strike the line G G^1. This is the heel of the intercostal clip to floor No. 41½, at the fore end of the intercostal, or at the line B D, which will be the heel of the intercostal clip to floor No. 42.

If the shell strake of this intercostal girder be an inside strake, the line A B, will be the heel of the intercostal clip to shell, between floors No. 41½ and No. 42. If an outside strake, simply add the thickness of the shell plating.

The line E^1 F^1 is the heel of the intercostal clip to tank top, between floors No. 41½ and No. 42. As previously stated, the floor to shell and floor to tank top clips are on the after side of the floor.

We shall have to make allowance for these bars at frame No. 42, and assuming that they are both 3½-inch by 3½-inch by .42 inch angle, we shall measure 4 inches from the point F on the line E F; and mark the point H.

Now, measure 4 inches from the point F on the line B D, and mark the point H^1, and then connect these points with a

straight line H H^1. From the point F^1, measure 4 inches on the line E^1 F^1, and mark the point J; and from the point F^1, measure 4 inches on the line B D, and mark the point J^1.

Connect the points J J^1, with a straight line; then the lines H H^1 and J J^1, are the shears for our intercostal plate, and the point H, the shear of the shell clip.

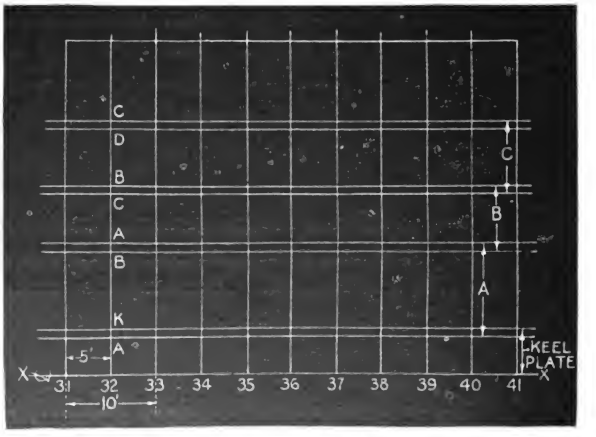


Fig. 57.—Method of laying down the lines of midship section.

The points H^1 J^1 are the shears for the floor clip and the point J, the shear of the tank top clip. These are all the necessary lines for the intercostal.

Developing Plates.—All templates of plates and angles for the midship section are made in the mold loft. In some cases, detailed drawings are made in the draughting room for each plate of this section. In that case, each plate template may be made separately. The advantage of this system is that if one of the templates becomes lost or is broken, another one

may be made by simply consulting the drawing of that special plate. In the case of the drawing that we show, however, the templates would have to be made together, as follows:

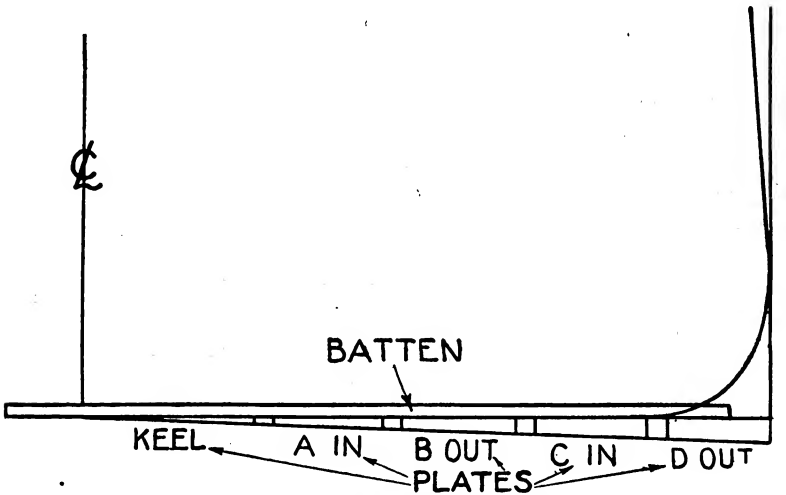


Fig. 58.—Method of picking up shell laps from the scrieve board.

The frame spacing, that is, a distance from the heel of one transverse shell bar to the heel of another transverse shell bar, is in the present design 10 feet, so the distance from the frame line No. 31 to the frame line No. 41 is 50 feet.

Put down a straight line, X X, shown in Fig. 57, a little more than 50 feet long. Then, on the line X X, which is the center line, space off the frame lines which will be 10 feet apart; frames No. 31, No. 33, No. 35, No. 37, No. 39, No. 41. Then, in between these points, spacing the floors which will be 5 feet on each side of each transverse, No. 32, No. 34, No. 36, No. 38 and

No. 40. Erect perpendiculars at each of these points (we will develop only this section to strake E).

Now, from the midship section frame lines on the scrieve board, pick up the shell laps, Fig. 58.

Get a batten of sufficient length to reach from the center line to the lap of the shell plates C and D. Mark on this batten the center line, lap of the keel and shell plates, lap of A and B; lap of B and C, lap of C and D. *This must be done very carefully so that the work may be accurate.* Remove the batten and it will look like Fig. 59.

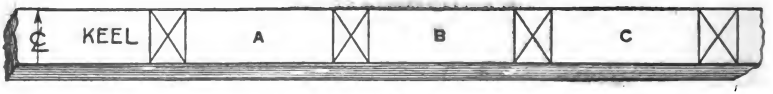


Fig. 59.—Batten showing the laps from the scrieve board.

Apply this batten on frame No. 31, Fig. 57. Have the center line exactly on the line X X, and mark the shell laps on this frame. Then, at frame 41, apply the batten in the same manner as No. 31, and mark the shell laps. Connect these points with straight lines, see Fig. 57.

Shell strake D, being the bilge strake, we will have to make allowance for its expansion. The most accurate way of doing this is as follows: Strake D, being an outside strake, it will be necessary to find the thickness of the strake on each side of it. On the blue print, we find the thickness of the strakes C and E are .56 inch. Reducing this to a fraction, it equals a little more than ½ inch; therefore, the molded lines, that is, the inside of shell strake D, is a fraction over ½ inch from the molded line of the scrieve board, as shown in Fig. 60. We will have to have a

batten a fraction over ½ inch in thickness; that is, thickness of shell strake, each side of strake D, and apply it on the molded line of midship frame, as shown. To find the thickness of shell strake D, refer to the blue print. It is also .56 of an inch. Have another batten of the same thickness as the other one, and nail it tightly against the batten which we have just nailed down, see Fig. 61.

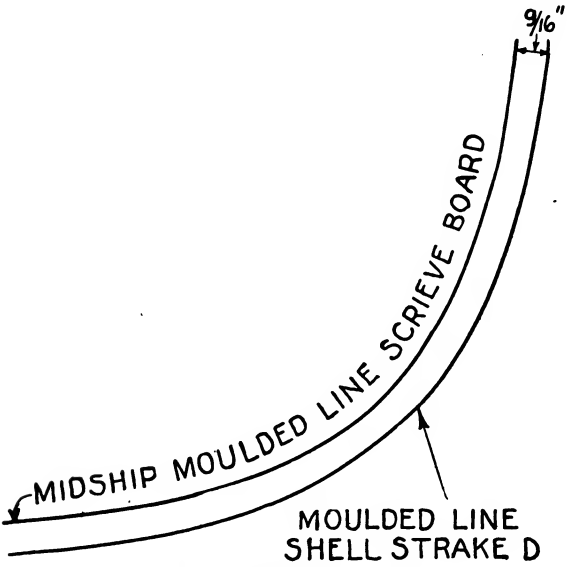


Fig. 60.—Showing the molded lines of shell on scrieve board.

Mark the laps on these battens; also the longitudinals, and the molded line of the tank top bar. This is done by squaring over from the midship frame line. Care must be taken to square these points over accurately or all the work will be wrong.

After these lines are marked on the battens, remove from the floor. Batten B is the same as the shell plate D. Apply batten B on frame line No. 31, having the bottom shell laps on batten B exactly corresponding with the shell laps C and D, see Fig. 57. Transfer the marks of the longitudinals and shell laps from the batten to the frame line No. 31. Do the same with frame No. 41, and connect these points with straight lines.

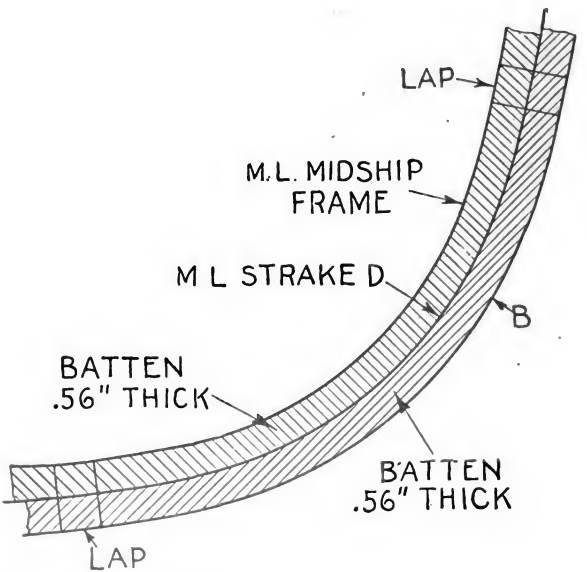


Fig. 61.—Obtaining the shell expansion of the bilge.

We now have the expanded length of the bilge strake; also, these are all the plate seam laps for strakes A, B, C and D. The keel plate is made in half template, so only one seam lap is shown. The plate laps, forward and after laps, are put in, according to the drawing. Sets will have to be made for the

bilge strake. Make it a template to the molded line of the bilge strake, as shown in Fig. 62. Mark the plate laps on this template; that is for the man at the rolls to apply the template to the plate.

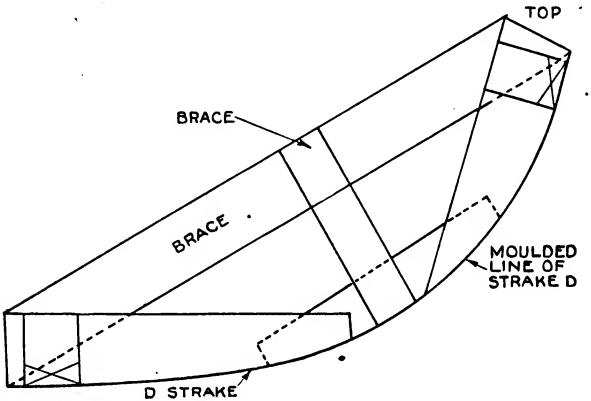


Fig. 62.—Template of the shell (bilge).

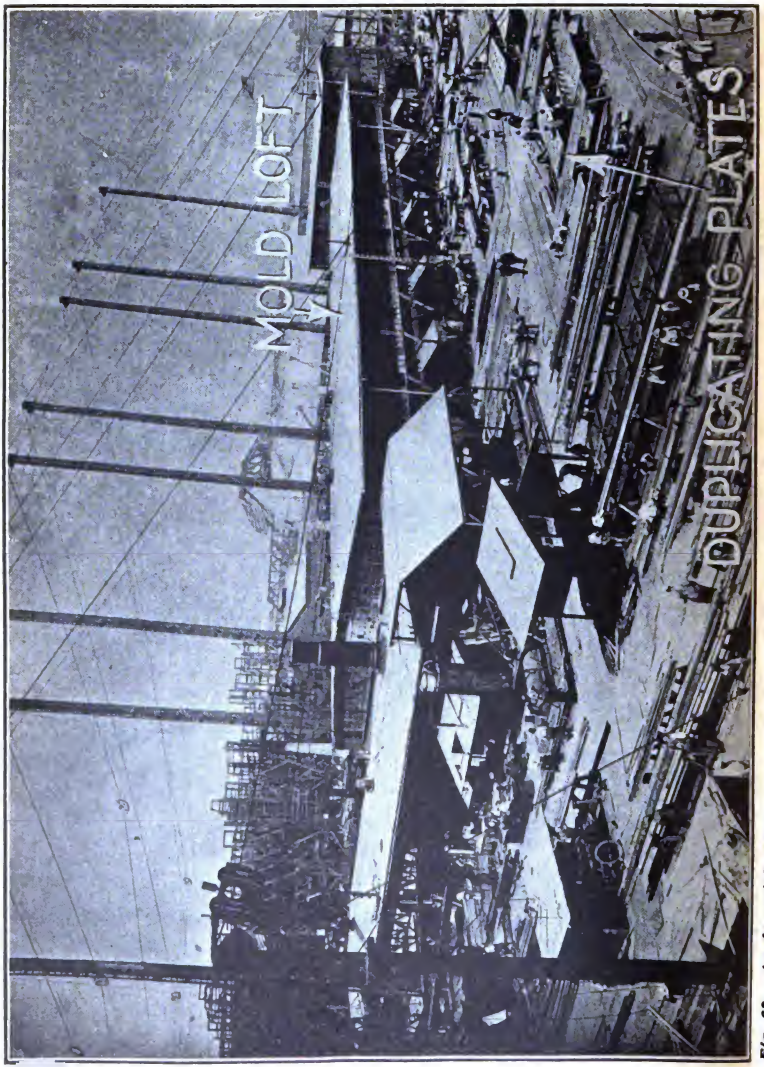


Fig. 63.—Angle smith shop.

LINERS

In riveting two pieces of metal together, it is important that the pieces touch. In many cases it is impossible because of the lap of plates.

For instance, when a plate passes over the end or edge of another plate and they are supported by bars, there will be a space on account of lap between the plate and the bar.

The plate and bar cannot be riveted until this space is filled in with a piece of steel or iron, called a *liner*.

Liners are used especially at the butts and any place where there is a space between two parts that have to be riveted and the parts cannot be brought together.

Liners are either flat (parallel) or wedge shaped (tapered), and are about eighteen inches long.

Liners, as a rule, taper, although occasionally it is necessary to use parallel liners, which come in various thicknesses; they are in most cases "*lifted*" from the ship.

To *lift* a liner from the hull, the first thing is to find out the length, width and thickness required.

Fig. 64 is an example where a tapering liner is necessary. Where the rider plate overlaps, course A is ½ inch in thickness you will readily see that in preparing the liner, the thick end will be ½ inch in thickness, and will rest against point X.

From point X, measure to point D, and that will be the length. It will be noticed that a bar runs underneath the plates at that

point. You will measure the flange, as the flange touches on the plates. We will say the flange is 3½ inches in width. Therefore, allow the width of the liner to be a little wider than the width of the bar—say, four inches for the width of the liner.

By slipping a piece of cardboard of the desired length and width, between points X and D, and placed in the center, the holes of the plates can be transferred to the cardboard, by inserting a pencil and marking around each hole required. Without

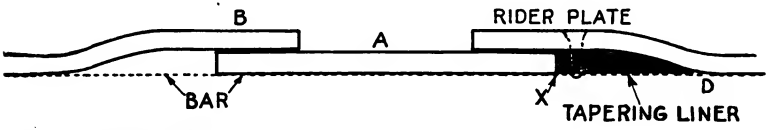


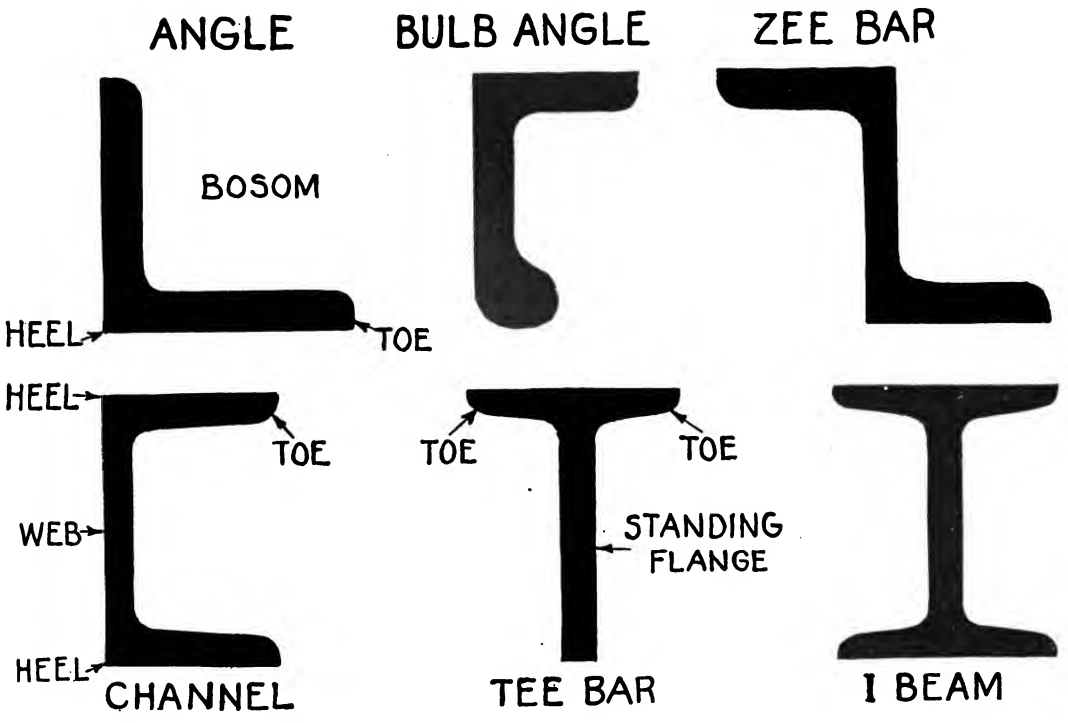
Fig. 64.—Tapered liner.

draw the cardboard, and procure from the reserve stock of liners a liner of the size required.

Transfer the holes from the cardboard to the liner.

No markings are necessary, because when the liner is ready, it is placed in position and a bolt put through just to hold it in place.

Where more than one liner is to be made, it is good practice to mark with crayon, and number the position of each so as not to be confused later.



Figs. 65 to 70.—Bar shapes.

DUPLICATING

Bars or Shapes.—Templates for bars have the heel edge planed smooth, so in referring to the heel of the template, it means its smooth edge; this edge corresponding to the heel of the bar.

On bar templates, the template usually applies on one flange only, therefore, the holes on the other flange of the bar are shown on the template as short lines drawn from heel, and a half circle mark drawn around them with crayon, and the distance of the holes from the heel of the bar is shown.

For instance, the template reads: *gauge holes, 2 inches,* then the distance from the center of the holes to the heel of the bar would be 2 inches.

Bars or angles come in several shapes and of different sizes and thicknesses. They are as follows: Angles, T bars, Channels, Bulb Angles, I Beams and Z Bars. See Figs. 65 to 70.

Duplicating a Clip.—We will take the clip on floor twenty-four to the intercostal, on longitudinal No. 16. On the template we find the following markings: *Top—L*15*—F*24, 3 *inch by* 3 *inch by* .38 *inch angle,* $\frac{7}{8}$ *inch holes, gauge* $1\frac{5}{8}$ *inches,* 1 *R* (*T. S. UP*),—1 *L* (*O. S. UP*),—*Hull No.:* This means that

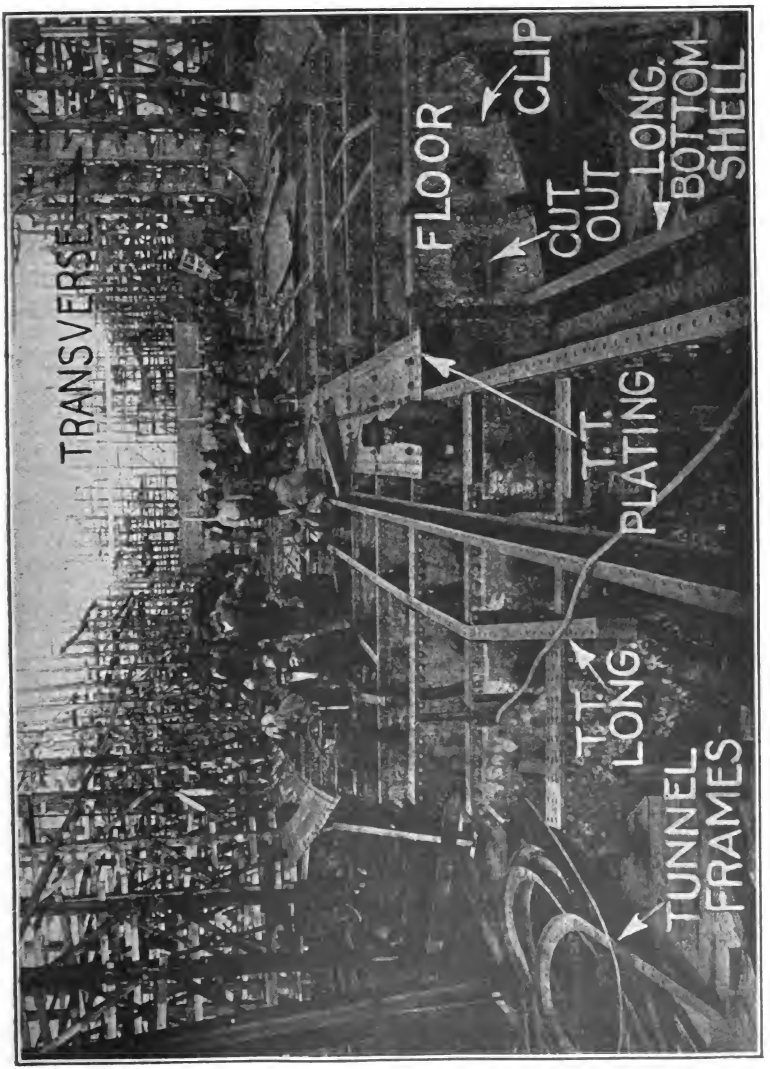


Fig. 71.—Constructing the double bottom.

we have to have an angle, each flange being three inches from heel to toe, and .38 inch in thickness, see Fig. 72.

Place the template on the bar, having the face of template up for right, and have the heel of the template correspond exactly with the heel of the bar. When this is done, secure with clips and with the prick punch put in rivet holes and shear marks that are drilled in the template. Then, for the holes on the other flange of the bar, take the small square and square the lines that are marked on the template for the gauge holes down to the flange, away from the template.

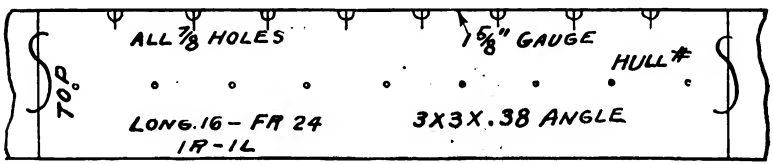


Fig. 72.—Template of a clip.

Mark "*top*" on the bar and remove template. It reads on template: to *gauge these holes* 1⅝ *inches*, so on each of the lines that were squared down, measure 1⅝ inches from the heel of the bar and draw a line. Where this line crosses the line that was squared down from the template, is the center of the rivet hole.

Make a center punch mark here; also, center punch the prick punch marks and shear marks, stencil top L16—F24, and the hull number, and it is now ready for painting on the bar the description, hull number, etc.

Channel Bars.—To transfer a bar template to steel, one must have a thorough knowledge of its position on the hull. Whether

the port or starboard, or the heel inboard or outboard, any such mistake will put the bar on the scrap pile. When a template is received for you to transfer, by all means read every description so that you will be less liable to make a mistake.

Remember that, although a template may have rivet marks and description on one side, it does not mean that the template will be transferred from that side. It may read, 1 *OFF*, *O S Up Port* only. It is an actual fact that many experienced men have made this mistake.

Suppose a template should be marked wrong, for instance, *T S Up Starboard*, instead of *T S Up Port*, and if the template be reversible—that is, one side for port and one side for starboard, two bars would, therefore, be spoiled. They could not be fitted to the hull because each heel would be reversed from its right position.

To a "green man," it looks very complicated, but with a little forethought, it can easily be understood.

To the student I would advise this system to overcome the difficulty. Have, if possible, **to your left, the after end; to your right, the fore end.** You would therefore be facing the port side and at your back would be the starboard side. Say, for instance, a channel bar must be gotten out, and the template is a web template—a template having rivet marks at the edge or heel for rivet holes for the flange of the channel and drill holes in the template for rivet holes for the web of the channel.

Place template on the web of the channel bar, with the after end to your left, with rivet marks for the flange away from you; that bar would be for the port side, if the heel is O B (outboard). See A, Fig. 73.

By turning the template over and having the rivet marks this time toward you, the bar would be for the starboard side, the heel O B (outboard), as shown at B, Fig. 73.

If it be desired to get out a starboard bar with the heel I B (inboard), follow the same instructions as given for A. It will readily be seen, by reversing the channel bar, the flange having

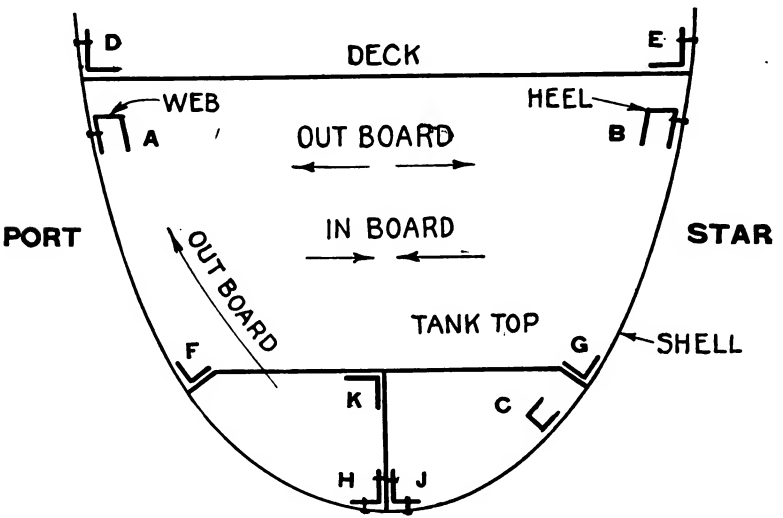


Fig. 73.—Position of bars on hull.

the rivet holes to go against the shell, will be in position of C; but this bar now cannot be used on the starboard side with the heel O B (outboard), because it could not be placed in position, as you will see by reversing the channel bar C, to have the heel O B (outboard); the holes in the flange would not be against the shell plating, and it could not be turned around as the after end would be in the fore end position.

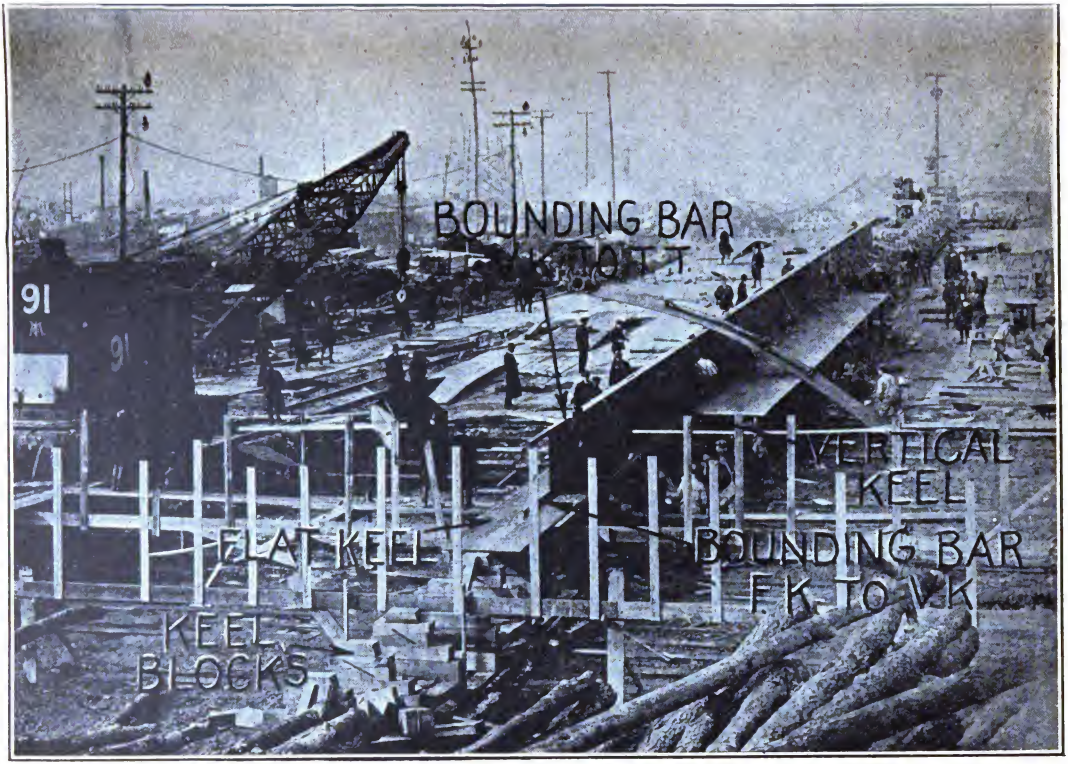


Fig. 74.—After the keel is laid.

The rivet holes are not universal, therefore, the bar would not fit. The punching and marking are similar to other bars.

Angles (Bars).—These bars are used to support and stiffen connecting plates at different angles.

In duplicating or laying off angle bars, the main feature is, when any particular template is applied to a flange, that flange must rest against the part it is intended for; otherwise, if applied on the wrong flange, the bar would not comply with the blue print reading, and therefore would be spoiled and couldn't be used again, except at great expense.

Take, for instance, a gunwale bar (angle), as shown at D and E, Fig. 73. The bar is used on both sides of the hull, port and starboard. Mistakes can be avoided, if the template be turned over (flopped). The same applies to the margin bars F and G and bounding bars H and J. But should bounding bar K, Fig. 73 (vertical keel to tank top), have to be gotten out, it would be necessary to place the template with the proper side up, as the bar in the illustration shows only on the port side; therefore, it is a port bar only.

It is obvious that by keeping the **after end to your left, and the heels of template and bar away from you,** the bar will be in the proper position for the hull, if the gauge holes on the edge of template are for the tank top and the holes drilled in the template are for the vertical keel.

Before adjusting the template to a bar, always, if in doubt, procure a blue print, and have the bar in position—the way it is placed on the hull. Then, mark each flange with crayon or chalk. Shell, tank top, etc., after end and fore end, port or starboard. Then, when the occasion arises for you to turn over the bar, its position will not be so confusing, because you have

the flanges marked, and as the template is so marked, the system is simplified.

When two templates are made, the same caution must be observed.

Bar Templates having "Apply" Templates for each Flange.—In some cases the shell bar connecting the transverses to shell has a separate template for the shell holes for those strakes that are lifted on the floor. These templates are known as the "apply" templates, as they apply with the template that has the holes to the transverse.

For our lesson, we will take transverse shell bar No. 25, between tank margin and main deck. For instance, this calls for 6-inch by 6-inch by .42-inch angle, and this bar will have to be shaped by the angle smith.

After the angle smith has bent the bar to the shape of template, and the bar has been bevelled, place the bar and laying off template together, and check them up to see if they correspond as to shape. If not, send them back to the loft and have the loftsman check them on the scrieve board. If the templates be O. K., and the bar do not fit the templates, send the bar back to the angle smith to be bent over again. We will take it for granted that the bar and templates are exactly alike.

Then clip the template on securely, and with the prick punch, put in the drill holes that are in the template.

In those strakes that are lifted on the ship, gauge holes will be found on the template, so with small square, square these gauged holes onto the flange from the template. In those strakes that are lifted on the floor, use the apply templates.

On this template, the top will be marked; also the pitch marks; also there are corresponding pitch marks on the other template.

These pitch marks are shown on the templates with arrow marks, and are marked with the abbreviation, P. M. (pitch mark).

Lay the apply template on the bar, having the top toward the heel of the template, even with the heel of the bar, and the pitch marks on both templates must correspond exactly. Of course, if the apply template is for strake D, it will have to apply on that place on the bar, where strake D is shown on the other template.

When the template is in place, clip it down securely and prick punch the holes in the bar; then remove template.

If more than one strake, follow the above instruction for the others.

After the holes are all duplicated from the apply templates, remove the clips from the large template, and take same from bar. At the lines that were squared onto the bar from the template, gauge holes as shown to be 2 inches and 4⅝ inches; that is, at each line, measure from the heel of the bar 2 inches and mark a line where this line crosses the other line and is the center of the first rivet hole. Then, on the same line, measure 4⅝ inches from the heel of the bar and this is the center of the second rivet hole. All holes on this bar will be gauged 2 inches and 4⅝ inches from the heel. Center punch the rivet holes and shear marks, stencil *Top* and *T* 25 *Port* on the bar, and it is ready for painting.

Joggled Bars.—Some bars are joggled to do away with a liner. Take the case of the tank top—the center or rider plates are on the top of course A plates, and B course plates are on the top of course A plates, as in Fig. 75. Therefore, if the floor to the tank top be not joggled, either parallel or tapering liners would have to be fitted between the bar and all outside plates.

It will be remembered that all plates which are an inner strake, or course, are on the molded line, and the bar is made to the molded line. Then the plates that lap on the outside of these plates are outside plates, see Fig. 64. When the bar is joggled, the liner is eliminated, as in Fig. 75. These bars are either joggled by the blacksmith or in a hydraulic or electric squeezer. Two templates are required for work of this kind; one, for the blacksmith, known as the **squeezer template,** and this template has only the joggles in it, the rivet holes being omitted and a piece of tin is tacked on at each joggle in order to

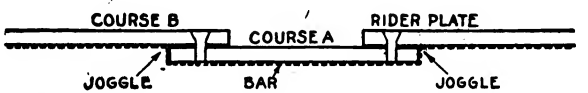


Fig. 75.—Joggled bars.

strengthen and keep the template from burning. There is also a **laying off template.** This is the one that the shipfitter uses. It has all the rivet holes and joggles on it.

The blacksmith and laying-off template joggles must correspond exactly. If they don't, send them back to the loft room and have them checked up to see which is wrong.

In applying the laying-off template on the bar, have the joggles in the bar and those in the template even. This template will apply on the flange that isn't joggled; that is, the flange to the floor plates. After the template is laid and clipped securely on the bar, duplicate the template, as in previous lesson.

Bulb-Bar.—For this lesson, we will take shell longitudinal No. 16 between frames No. 24 and No. 25, as shown in Fig. 77.

Fig. 76.—Looking forward.

The bar for this template is 12 inches by 3½ inches by ½ inch bulb angle. As the template is made to apply on this standing flange, that is, the 12-inch flange, the 3½-inch flange connects to the shell. Apply it on the standing flange; that is, to the planed edge, exactly even with the heel of the bar.

When the template is in this position, clip it firmly, and be sure that the template is held securely. Then, with a small square, square the lines for the rivet holes and shear marks from the template down to the 3½-inch flange of the bar. Now, with the prick punch, put in the shear marks, and rivet holes on the 12-inch flange.

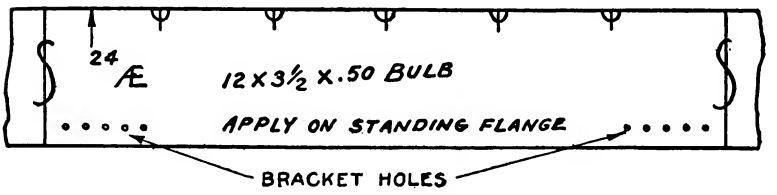


Fig. 77.—Template of a longitudinal.

Remove template from bar and with the 2-inch gauge, draw a line 2 inches from the heel of the bar along the 3½-inch flange. Where this line crosses the lines which were squared off from the template, make a punch mark, except at the shear. These are the holes to be punched on this flange.

Those rivet holes which are drilled in the template which are for the 12-inch flange, make larger with the center punch. With the soap stone, draw in the shear marks. Then, at the after end of the bar, stencil the location, etc. The bar is now ready for painting.

Water-tight or Oil-tight Bulkhead Bar to Shell.—This

bar would be duplicated in the same manner as the transverse bar. The difference would be in the spacing of the holes in the flange to the bulkhead; the holes would be C S K (countersunk), and therefore, the toes of the bar would be planed for caulking, the bar should be marked for planing, otherwise the bar would be placed on the hull by mistake before being planed.

Shell Template.—Duplicating or transferring plate templates

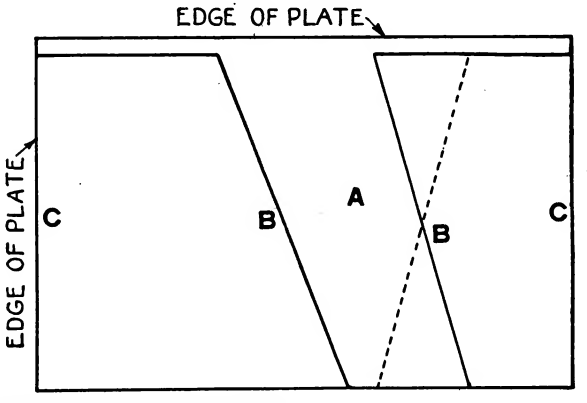


Fig. 78.—Placing two templates on a plate.

requires one to have at least a working knowledge of each plate, and if possible, its position on the hull, so that if the template be marked wrong, as sometimes occurs, the mistake will be noticed in time before the template is transferred and sent to the punch shop.

It is also sometimes necessary to have separate templates for port and starboard.

Caution must be observed in getting the port template for the port side only, etc.

You can see how important it is for one to know exactly what one is doing, because when a plate is spoiled, it cannot easily be replaced, and is of no further use but for scrap and to be cut up.

When this happens, there is great delay. Sometimes such material has to travel hundreds, if not thousands, of miles. Remember, any plate on the hull, is not independent of itself; that is, each relies upon the adjoining plate for its support and strength.

In many cases two plate templates can be placed on a steel plate. Care must be taken to prevent waste, if possible. If two templates be oblong or square, they can then be placed next to each other, but should the plates on the side have a slant or curve, by placing the templates as shown in Fig. 78 they will fit on the plate so as to leave a piece A, which may be used for another part.

The dotted line shows the wrong way. Better use could be made from the scrap piece A, although it may occur that such a piece as the reverse is desired.

Never allow the edges C C, to be away from the edge of plate, as that would necessitate four different burnings, or shear one each at C C, and in the middle at B B.

When you receive a template to be transferred, always read the instructions carefully, because some changes may have recently been made.

When you have become familiar with the description and you have the proper side up; if a reversible template, you may place in position to be duplicated.

Before taking up this work, it will be best if the student understand the marks on the templates.

We will take shell template, strake B, No. 6, see Fig. 79. Always read what is printed on the template. Do this before applying same on plate.

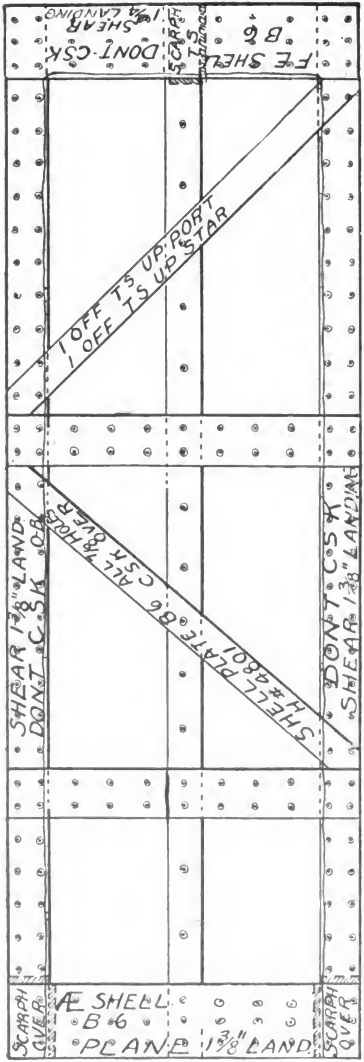


Fig. 79.—Shell template.

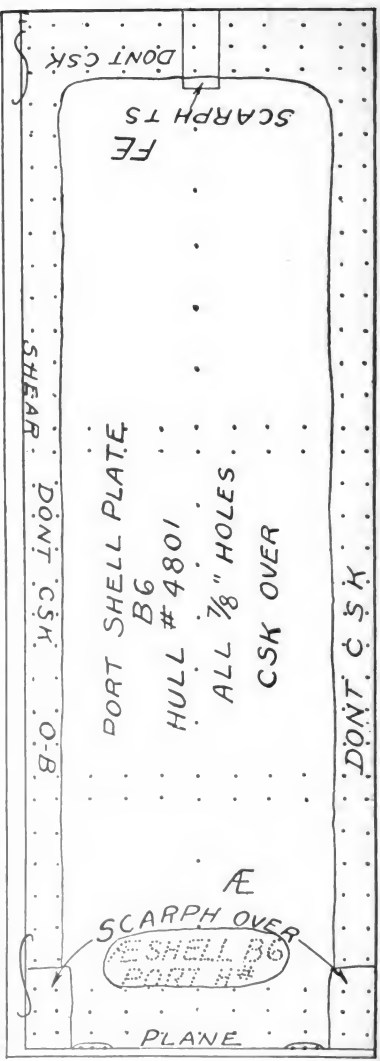


Fig. 80.—Shell plate.

We find this on the template: *Æ, Shell B* 6, 1 *Off, T S Up Port,* 1 *Off, O S Up Starboard—All* 7/8*-inch holes, C S K O, Plane* 1 3/8*-inch Landing.*

That means, the face side of the template, the side at which we are looking, when it is up, and the holes are countersunk over; it is a port plate. All the holes that are punched in the plate are 7/8-inch in diameter, and are countersunk, unless otherwise noted.

Plane, 1 3/8 *inch landing.* After the plate, marked as shown in Fig. 80, is sent to the punch shop, the edges of plate where the holes are C S K (countersunk), have to be smoothed and bevelled so that they may be caulked and made water tight.

Then, at the other end of the template, it is marked *F E, Shell B* 6, 7/8*-inch holes, Don't C S K, Shear* 1 3/8*-inch Landing, Scarph T S* (*this side*).

Lay the template on the plate and as we will lay off a port plate, the face side will be up. Start at the F E (forward end), and measure 1 3/8 inches from the center of the rivet holes to the edge of plate, and put a clip on the template and plate at this point. Then taking either side, measure from the center of the rivet holes to the edge of plate 1 5/8 inches; the template calls for a landing of 1 3/8 inches, but we will have to allow for the planing of the plate, and 1/4 inch is enough allowance.

When you have the F E (forward end), of the template, with the center of the rivet holes 1 3/8 inches from the edge of the plate, and one side 1 5/8 inches from edge of plate, put a clip at each corner and two clips at each side to hold template securely in place. Then, with prick punch, duplicate all the rivet holes and scarphing marks from the template to the plate.

When this is done take the clips off, but before removing template, mark the description on plate, the A E, O B, and port on the plates. This may be done with soap stone or chalk.

Then with center punch, that is, large punch, go over the plate and make all the prick punch marks larger, except the marks for the scarphing.

At the A E (after end), and at the I B (inboard), and O B (outboard), sides, measure 1⅜ inches from center of the rivet holes and snap chalk line one or more times. Mark on these lines the amount of landing. Draw lines at the scarphing marks the same as on the template.

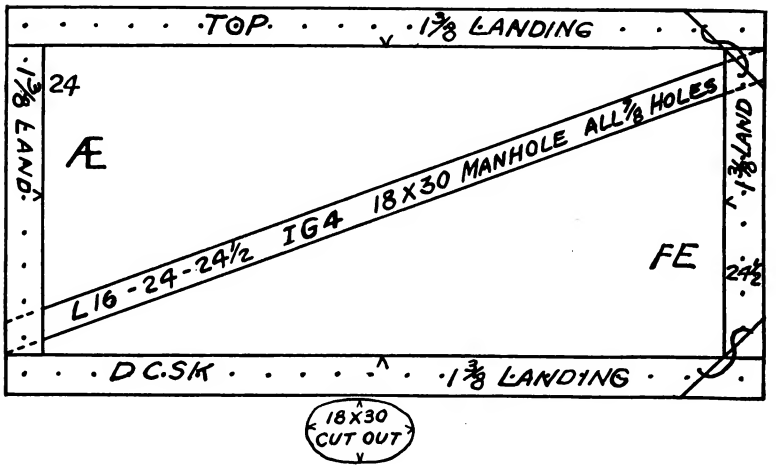


Fig. 81.—Intercostal plate.

At the after end of the plate punch the location of the plate B 6, port; also the after end and the hull number. This is known as stenciling the plate; then the plate is ready for painting the description, as shown in Fig. 80.

Intercostal Plate.—For this lesson we will take the intercostal plate L 16, between floors No. 24 and No. 24½, as shown

in Fig. 81. This plate is in the double bottom, at longitudinal No. 16, between floors 24 and 24½. The order mark on this is: *IG*4. So we will have to use the plate marked *IG*4. As there are no holes to be countersunk, the port plate will be interchangeable with the starboard plate, and vice versa. This is not always the case.

Note at the fore end of this plate the corners are cut off, shown by the shear marks. This is done to let the bars which connect floor to tank top and shell pass through. It might happen that these bars were on the after side of the floor, on the port side, and on the forward side of the floor on the starboard side or vice versa.

Lay the template on the plate, and beginning at the bottom, note the size of the holes and the landing. As the template calls for *all ⅞-inch holes, shear 1⅜-inch landing*, measure from the center of drill holes, 1⅜ inches to the edge of the plate.

Always try to use at least one edge of the plate as a landing, for that saves that much shearing on the plate.

As this plate comes in that part of the double bottom known as the "dead flat," the template will be a rectangle, all corners being square; so have the center of the rivet holes at 24½ inches at the fore end of the template, 1⅜ inches from the edge of the plate. In applying the template in this manner we have saved shearing the bottom and fore end of the plate.

Now clip the template down securely; take the prick punch and hammer at each drilled hole. There is also an 18-inch by 30-inch man-hole to be cut in this plate, as shown in Fig. 81. These holes are either punched in the plate by machine or burned out by the burner. It is put in for two purposes: To lighten, and to facilitate the passage of a man in the double bottom.

At the top and bottom, the forward and after ends of the template there will be noted an arrow mark.

Holding one end of the chalk line on the fore end arrow, and the other end of the chalk line on the arrow of the after end, snap the line connecting the two points. Connect the top and bottom arrows in the same manner.

These lines are used as a guide for cutting out the man-hole.

With soap stone, mark the top and after end on plate. This is only temporary.

Take clips off and remove template. At the top, measure 1⅜ inches from the prick punch mark, and snap the chalk line at these points. Do the same at the after end. These lines are where the plate is to be sheared. At the fore end, connect the prick punch marks with a straight line, the same as they were on the template.

Procure the 18-inch by 30-inch man-hole cut-out. On this template, it will be noted there are four arrows. Place this template on the plate, and have each arrow over the lines that were snapped, connecting the arrows that were on the intercostal template. With soap stone, draw a line around the template for the man-hole cut-out. When this is done, remove the cut-out template. With the center punch, make the prick punch mark for the rivet holes larger; also center punch the shear lines, having the punch lines about three inches apart. Center punch the line for the man-hole cut-out, as this is not a straight line, and the punch marks will therefore have to be closer together, about one inch apart.

At the top, stencil the word *Top* in small letters. At the after end, *Frame No.* 24, stencil *L* 16, *No.* 24—24½, *Hull number.*

The plate is now ready for painting. Draw a heavy paint mark around the top stencil mark to indicate its position. Then, at the top, paint the word *Top*, and so on, where description is necessary. The plate is now ready for the punch shop.

Bulkhead Plate.—In this lesson, we will take a bulkhead plate that has to be turned (flopped over), as shown in Fig. 83. For example, take bulkhead 25, starboard plate 11, it will be noted that port plate 10 is also on this template. The lap of these plates is on the port side of the ship, between stiffeners No. 1 and No. 2. Number 1 stiffener is on the center line. Then there is a port and starboard stiffener, No. 2, No. 3 and No. 4. Also starboard plate No. 11 is a longer plate.

After having secured the plate, place the template on it. It will be noted that the holes in the bottom of this plate do not countersink, and that they are *¾-inch holes*, and *shear 1¼ inches landing*, so that we can use this edge of the plate as the shear. Measure 1¼ inches from the center of the holes to the plate edge at the O B (outboard), end. These holes are ¾-inch countersunk over, and plane 1¼ inch landing. Therefore, we will have to allow a little extra plate on this edge for planing. If the plate edge be fairly smooth and straight, ⅛ inch is plenty allowance; but if not, better allow 3/16 inch or ¼ inch. *Always try to cut this allowance down to as nearly ⅛ inch as possible.*

The more the plate has to be planed off, the more the job costs, and it is in saving these little things that the job can be speeded up and the cost cut down.

We will take for granted that this is a fairly good edge, so measure 1⅜ inches from the center of the holes to the edge of the plate. When you have those O B (outboard) holes 1⅜ inches

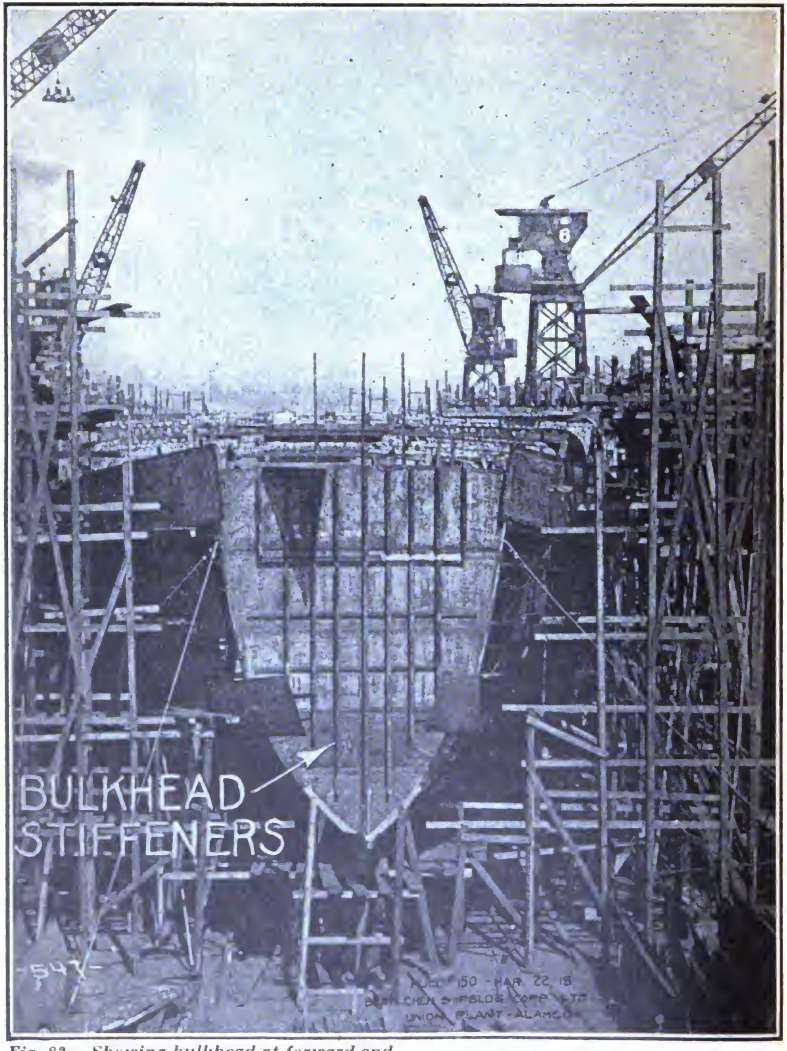


Fig. 82.—Showing bulkhead at forward end.

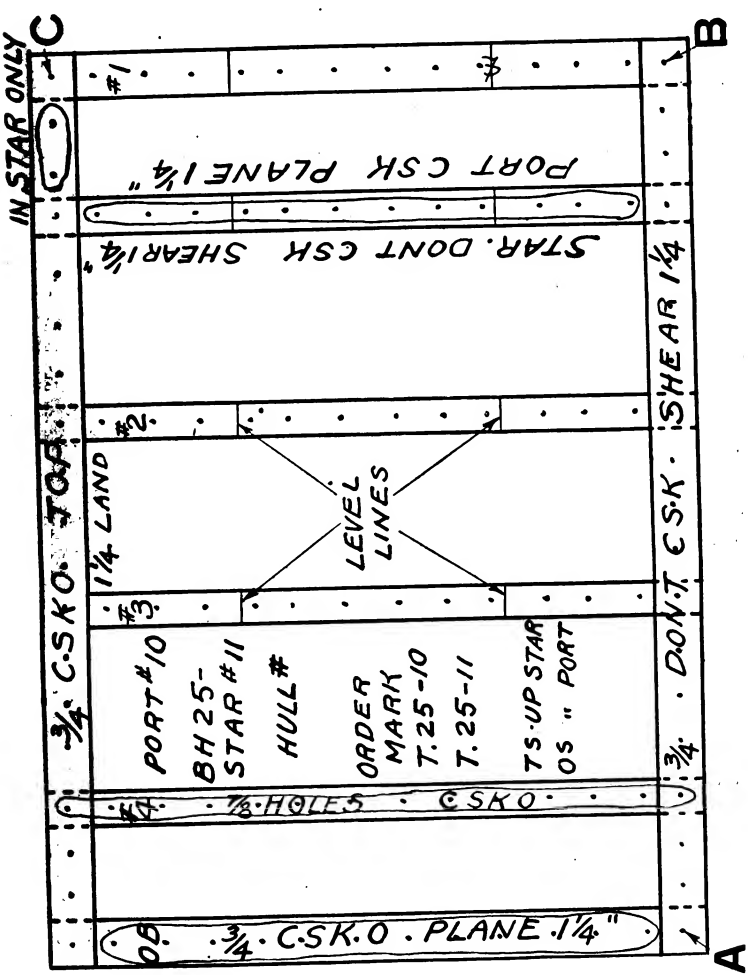


Fig. 83.—Shell template, port and starboard.

from the edge of the plate, and the bottom holes 1¼ inches from the edge of the plate, put the clips on to hold it securely. Then snap a chalk line from the hole in the corner of the plate at the bottom, O B (outboard), corner, see A, Fig. 83, and passing through the hole B to the edge of the plate.

If this line be 1¼ inches from the edge of plate the landing will not have to be sheared, but can go as it stands. If the line at the point C, happen to be about 1⅜ inches from the plate, that would pass, *but never less than* 1¼ *inch*. Then draw a line at the edge of the template, mark center line, and in doing this, have soap stone to a sharp edge.

Snap a line through the level lines to the edge of plate. This must be done accurately. Prick punch the holes into the plate, omitting the holes at the laps. Remove clips and mark the top of the plate and O B (outboard) edge.

Then turn template over, the same as you would the leaf of a book. Have the center line of the template correspond exactly with the line that was drawn on the plate, and also the level line of the template must correspond exactly with the lines that were snapped on the plate.

If the previous work was done carefully and accurately, and these lines do not fall over the lines on the plate, the template will have to be sent back to the loft room and checked up, as that would prove that the template had sprung out of shape.

It is one thing to pull a wooden template into shape and another thing to pull a steel plate into shape.

We will suppose that the template meets all requirements and is O. K. Now clip it down securely. This time, omit the holes of stiffener No. 1, which is on the center line, and put the holes

in the lap. When this is completed, remove clips and take template from plate.

Snap a line 1¼ inches from the center of the hole at both ends, and at the top. At the O B (outboard) and top, mark the line for planing. Every few feet or so put the plane marks. At the other end of the plate, mark the line for shearing; then punch the prick holes, stencil the top end, and at the O B (outboard) end, stencil *O B*, *B H No.* 25; *No.* 11 and *hull number*. When this is finished, the plate is ready for painting.

Study the template again carefully. All the holes are not the same size. The holes in the seams and laps are ¾-inch in diameter; those for the stiffeners are ⅞-inch in diameter, so care must be used in marking the holes. Also the template reads 1 *Off*, *T S Up Starboard*, plate No. 11 is the starboard plate, also some of it is on the port side, and when we turned or flopped the template over, we made the port side. Then all holes are C S K over; paint plate as per Fig. 83.

LIFTING

Lifting a Bracket Plate from Hull.—In the double bottom, the water-tight floors are connected to the tank top and shell longitudinals by triangular shaped plates called bracket plates. This is not the only place that bracket plates are found. But for our lesson, we will take the bracket that connects water tight floor No. 24 to longitudinal No. 15, shown in Fig. 84.

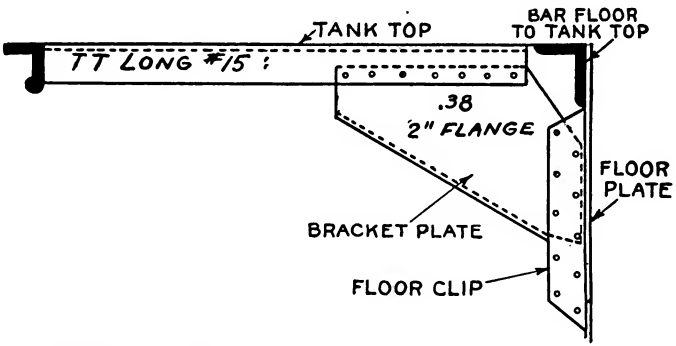


Fig. 84.—Bracket on the hull.

As the bracket has a single row of holes to the longitudinal, and a double row of holes to the floor clip, we will have to have a piece of 4-inch template wood and a piece of 5-inch template wood,

long enough to pick up the holes. Nail the two pieces of template wood together, as shown in Fig. 85.

Sometimes it is best to nail a cross piece, A, to act as a brace and hold the template in shape; but in lifting a small bracket of this kind from the ship, it is not absolutely necessary.

After tacking the 4-inch and 5-inch template wood together, apply the template to the tank top longitudinal No. 15, and the

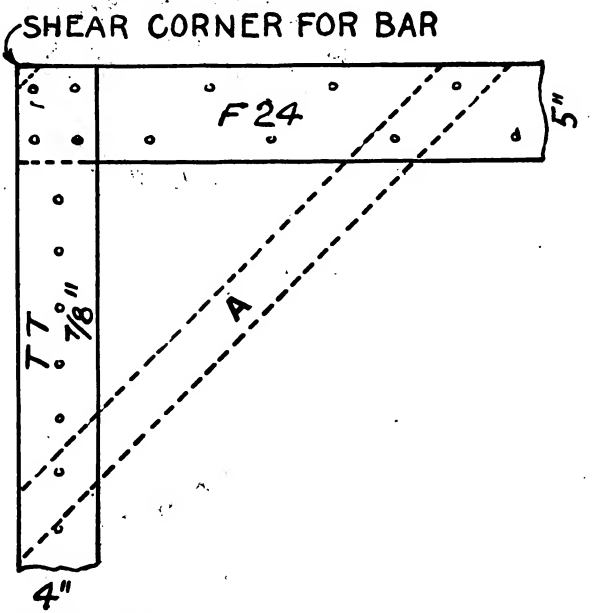


Fig. 85.—Bracket template.

floor clip on No. 24, and clip it securely. With a pencil, mark the holes. This is done by inserting the pencil in the rivet holes on the opposite side of the template wood, and running the pencil

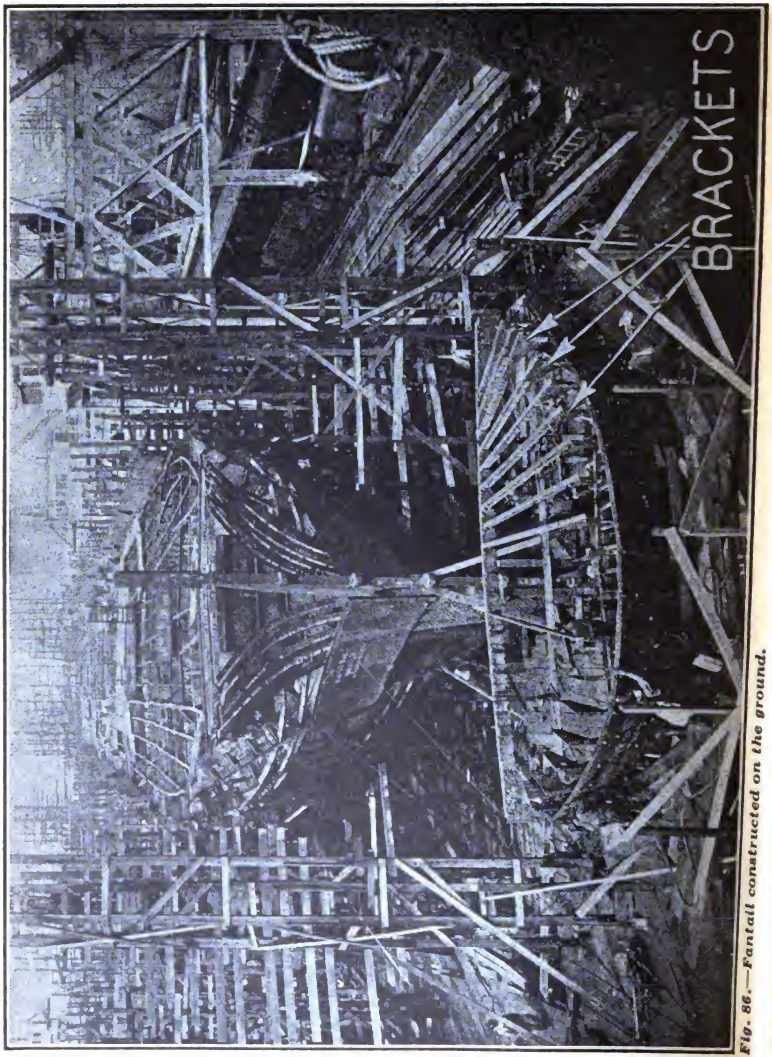


Fig. 86.—Pantail constructed on the ground.

around the circumference of the hole. This makes a circle on the template exactly like the hole in the bar.

After all the holes that are needed are marked on the template, take off the clips and mark *T T* for the tank top side, and *F*-24

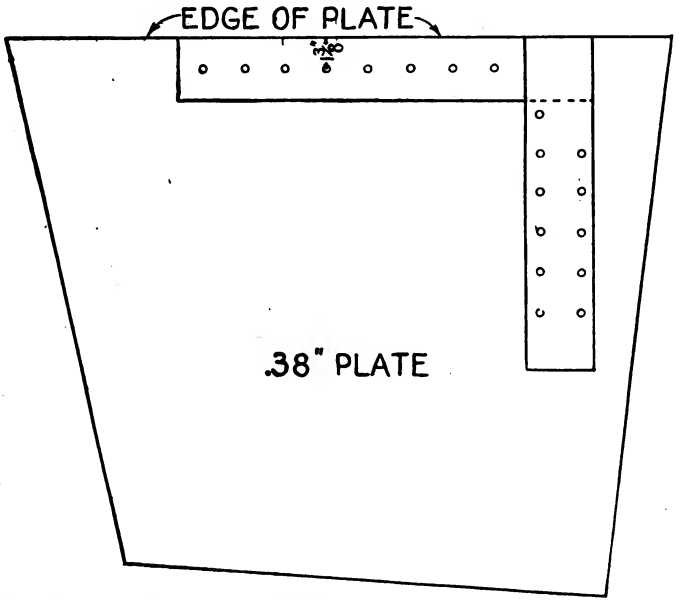


Fig. 87.—Bracket template on steel plate.

on the floor side of the template. Make a note in the corner of the template to shear for bar.

Before leaving the ship, find the size of the rivet holes and mark it on the template. In this case, they are $\frac{7}{8}$ inch in diameter.

The template is not ready to be laid off on the plate. In Fig.

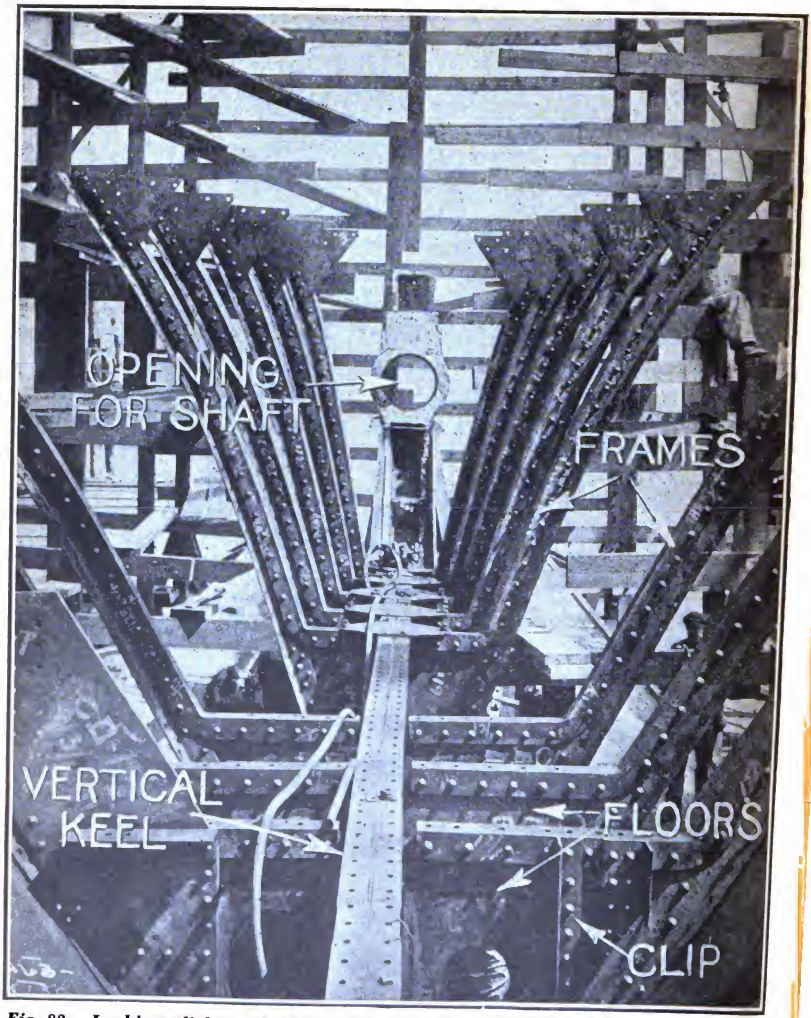


Fig. 88.—Looking aft from shaft tunnel.

84, the bracket plate is marked .38 inch in thickness· also note this carefully: that it has a two-inch flange. Lay the template on the plate, having the center of the longitudinal holes 1⅜ inches from the edge of the plate, as shown in Fig. 87. **It might be well to remember that small plates of this kind should always be taken from the scrap pile.** Clip the template securely to the plate. With prick punch, mark the center of

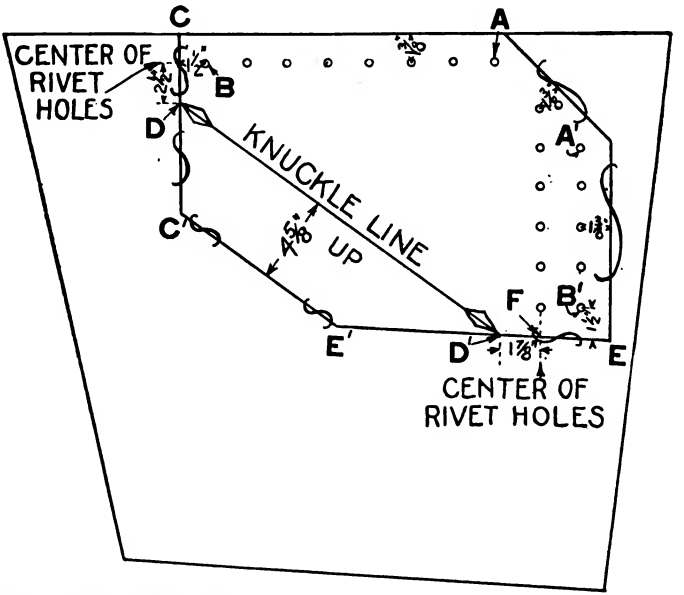


Fig. 89.—Bracket construction.

the rivet holes on the plate, as the holes are not drilled in the template.

Generally, the punch will stick to the wood. **Don't jerk the punch back and forth** to get it out. If you do, you are liable to shift the template

and ruin the plate, because the holes wouldn't be in the proper position. The best way is to give the punch a couple of turns and pull straight out.

When the holes are all put in, remove clips and take the template from the plate. Measure 1⅜ inches from the holes that are in the floor clip and snap a line. This is the shear line of that side of the plate, see Fig. 89.

Measure 1⅜ inches from the hole A, and the same at A^1. This is the shear for the corner of the plate. It will be remembered that we made a note on the template for this shear. Now, measure 1½ inches from the center of the last hole in the longitudinal, see hole B, Fig. 89; and this is the shear line. Produce this line at least 6 inches from the edge of the plate. Then from hole B^1 measure 1½ inches, and this is the shear line.

Before putting up the other shear line, we will have to locate the knuckle line. The holes in the tank top longitudinal are located 2 inches from the heel of the flange, opposite to the flange that connects to the tank top plating; as we will allow about ½ inch for clearance, measure on the shear line C C^1, 2½ inches from the center of the rivet holes and mark the point D. The floor clip frame 24, the holes are 1⅜ inches from the toe, allowing ½ inch for clearance. Measure 1⅞ inches from the center of holes, point D, on the shear line E E^1, and make the point D^1 connect the points D and D^1 with a straight line, and this is our knuckle line.

The print calls for a 2-inch flange. In reality, we are making a bar out of this plate, and that measurement is taken from what will be the heel, see Fig. 90 which will explain this. As the thickness of our plate is ⅜ inch, we will have to subtract this from the two inches to allow for the expansion of the plate. So, measure 1⅝ inches from the knuckle line and snap a line. This is

the shear line. We now have all the shear lines for the plate. Stencil and paint the plate and it is ready for the punch shop.

In knuckling plates, always knuckle them up. If you do not, the plates are liable to crack at the punch marks, thereby spoiling the plate.

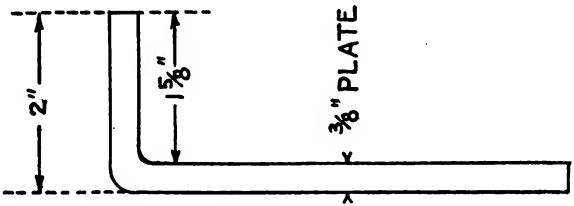


Fig. 90.—Construction of bar from plate.

Lifting a Bosom Bar on the Ship.—For example, we will take the bar between the gunwale bars, between frames No. 47 and No. 48, shown in Fig. 91. As these bars are 3½ inches by 3½ inches by .42 inch angle, we will procure a piece of cardboard of the desired length (about two inches) and wide enough (about seven inches) to fit the bosom of the bars. Next, fold the piece of cardboard, making it about 3½ inches wide, double, but do not break it. Then apply this cardboard to the inside of the bars or bosom and have it extend each side of the butt so that it will take in two holes on each side of the butt of each bar. Then hold the cardboard securely and be sure that it does not move.

With the ball end of your hammer, pound the cardboard where each hole comes. This will cut a hole in the cardboard exactly where it comes in the bar. Make a hole in the cardboard for each one in the bar, as shown in Fig. 91.

Mark the description of the templates and the size of the holes, and where it goes on the ship. Now you are ready to lay this cardboard template off on the steel bar.

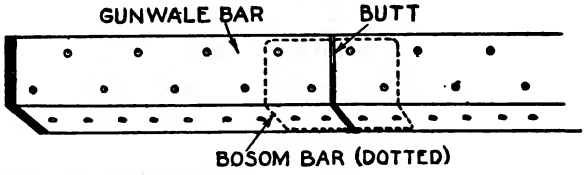


Fig. 91.—Bosom bar fitted inside a gunwale bar.

Remember, the gunwale bars are 3½ inches by 3½ inches by .50 inch angle, and the bosom piece fits inside of these bars, and

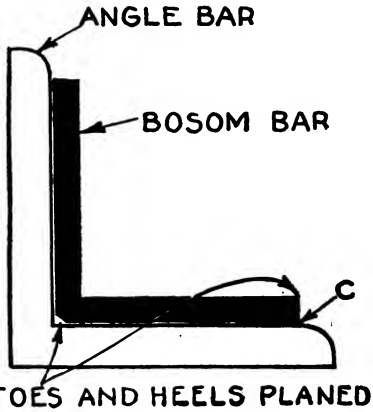


Fig. 92.—Cross section of bosom bar.

the toe of the bosom piece must set in about ⅛ inch from the toes of the gunwale bars, so that it may be caulked and made watertight; so, therefore, we will need a piece of 3-inch by 3-inch by .50-inch angle of the desired length.

HATCH COAMING
BOLTER UP
GUNWALE BAR

Now apply the cardboard template on this angle, having the side we hammered the rivet holes in, applying on the bar.

Hold this template securely on the angle and center punch, exactly in the center of the holes which we marked on the ship. Then remove template and allow about 1½ inches landing on the after end and fore end for shearing. Then have the heel and toes planed and the corners sheared off and the rivet holes countersunk, and the bar is ready to be placed on the ship. *Note the*

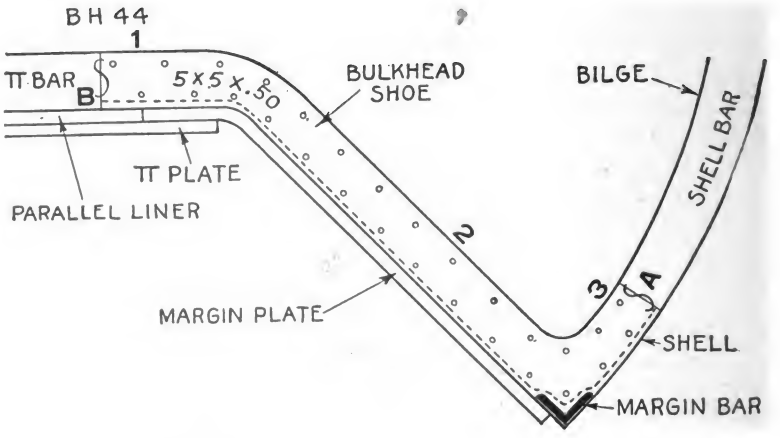


Fig. 94.—Bar of water tight shoe.

heel of all bosom pieces must be planed, otherwise they would not fit into the bosom of the other bars. This may readily be seen in Fig. 92.

Lifting W T (water-tight) Shoe.—For this lesson we will take W T shoe in the bilge at bulkhead No. 44. Have the bulkhead shell bar in place, and bolt it up securely; also the bulkhead to tank top bar, as shown at A and B, Fig. 94.

It is a good idea to have these bars riveted, and then we will know that the bulkhead plates will not shift, but this is not necessary.

As we will have to pick up a double row of rivet holes, the same being for a 5-inch bar, we will need some 6-inch template wood. After securing this wood, tack it together in the shape shown in Fig. 95. This shape is made by first applying No. 1 to the bulkhead and tank top, the edge of template wood resting on the tank top and the width against the bulkhead, as shown in Fig. 95.

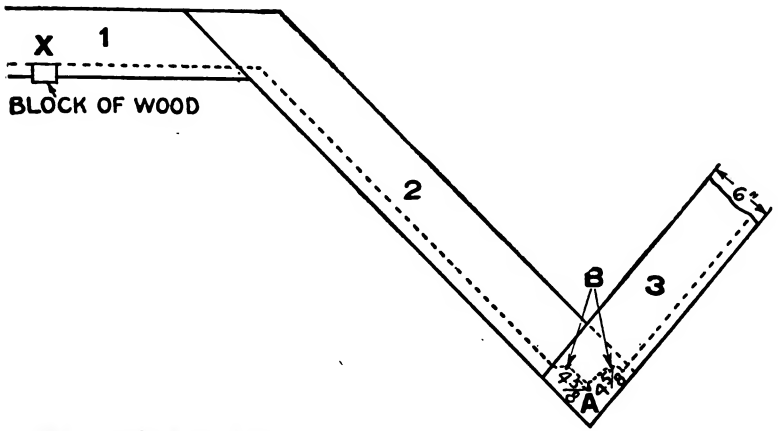


Fig. 95.—Template of water tight shoe.

Hold the template wood securely in place by clips. Then taking piece No. 2 and holding it against the bulkhead and margin plates. Tack No. 2 and No. 1 together at their laps.

Now, placing No. 3 against the bulkhead and shell, tack No. 2 and No. 3 together, giving the rough template as shown in Fig. 95.

Take a small piece of wood, about ½ inch in thickness, and hold it on the tank top plate (see X), with a pencil draw a line, using a block of wood to guide pencil around the template. This gives the shape of the bar, as shown by the dotted line, Fig. 95.

From the margin bar, measure 4⅝ inches from the bosom toward the toe, and this is the length of the joggle to clear the margin bar. See A to B, Fig. 95.

Take the template to the band saw and cut the template carefully on this line. After the template is cut, take it back to the ship, placing it in the same position as before; the template will now fit the ship accurately.

If the heel of the template, that is, the part we have just cut, do not fit to the tank, margin plates, shell plates and to the bosom of the margin bar, plane the heel down until it does make a perfect fit. When this is all done, hold the template securely in place by clips. Then, going to the other side of the bulkhead, mark all the required holes in the template.

This is done by inserting the pencil in each and every hole that is covered by the template, and running the pencil around the circumference of the hole, so as to leave a circle mark on the template wood.

After marking the holes (this is usually done by the helper), come back on the side of the bulkhead the template is on, and this is the side of the bar that has to be fitted to.

With square, pick up the holes in the margin and shell plates. This is done by holding one leg of the square against the template, and having the edge of the other leg pass through the center of the rivet hole. Then make a mark on the template at the point of the square, see A, Fig. 96.

As we have to pick up a double row of rivet holes, the gauge will be different, so for those holes which are nearest the bulkhead, mark the corresponding mark on the template with red crayon. For those further away from the bulkhead, mark with blue crayon. After all the holes have been marked on the template, put the shear marks on. These are where the tank top bar butts or shears to the shoe and where the shoe butts to the shell bar, as shown at A and B, Fig. 94.

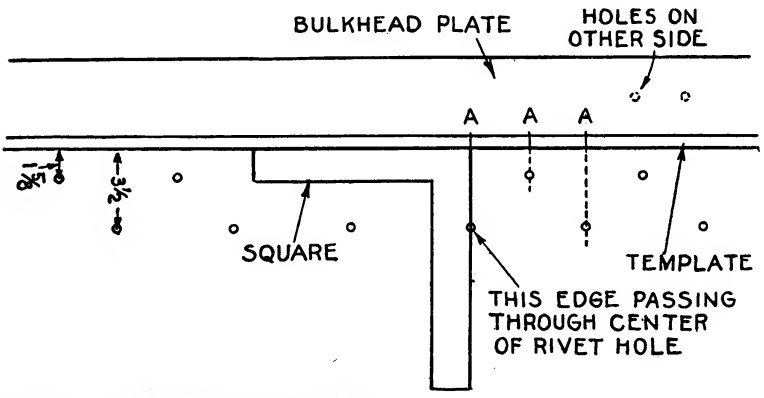


Fig. 96.—Lifting holes of water tight shoe.

This bar, being in the forward part of the ship, it will have to be beveled. The reason for this is that as we near the forward end of the ship, the frames run closer to the center line until they meet at the stem; consequently, our bar being in the apex of a triangle, its angle (90°), will have to be changed to fit this triangle.

This angle may be gotten with a bevel square. Adjust the square, and this time we will have to hold heel, not the

flat surface, to the shell and against the bulkhead, and tightening the set screw, we obtain bevel.

Before taking the square up, mark the template at this point and number this mark No. 1. This should be at the end of shear of the shell bar. Then, take the square and holding it against the plane surface of a 4-inch piece of template wood, draw a line to the edge of the square. Mark this No. 1, open bevel. The bevel will have to be taken at more than one place, generally near the shear mark, at the margin bar and between two points, which is sufficient.

As you pick up the bevels, number them on the template and on the extra piece of wood that you are using for the bevel marks. The bevels to the shell will be open. Those to the margin plate, closed, and those to the tank top, open.

After we have picked up all the necessary bevels, holes and shear marks, mark the side to the shell, *shell*, that side to the margin, *margin*, to the tank top, *T T*, what side of ship it goes on, in our case it is the starboard, therefore mark *Star* on the template. Also mark the red crayon holes, those being near the holes, gauge 1⅝ inches; the blue holes gauge 3½ inches. All the work that can be done on the ship is finished, so remove template.

A shoe of this kind has to be made by the blacksmith on account of its shape, and that requires a blacksmith template, to be made. So, make another template, the exact shape of the one we have just made on the ship. The side of the template that has the circled holes, will be this side up *T S Up*, when applied on the bar; therefore, make the blacksmith template from that side.

Now we have two templates. The one that was lifted on the ship is the laying off template, and the duplicate of this is the blacksmith template, so transfer the bevel marks from the laying

off template to the blacksmith template, numbering them the same.

As these numbers would mean nothing to the blacksmith, we will have to put the bevel marks in; so, mark degrees, opened or closed bevel.

Secure the bevel board from the loftsman. Then, by placing the bevel square back on the 4-inch piece of template wood in the same manner as was done at first, it will set the square to the same angle as we had on the ship. We will set it back to No. 1, tighten the set screw so that the square will hold its shape. Place the square on the bevel board, having the edge of the square that was against the small board, against the bevel board. Move the square up or down the board until the other edge fits the line perfectly; then, the number on this line is the amount of our bevel. We will say, therefore, that the line number is 6. So this point No. 1 opens 6°. Mark this on the blacksmith template. Do the same with each of the other bevel points, marking them open or closed, which ever they may be.

Put the shear marks on template, and it is ready for the blacksmith.

Measure from shear mark to shear mark, holding the tape against the heel of the template, and this gives us the length of the bar. We will say six feet two inches; but the blacksmith will need a little spare or longer bar to work with, so order a piece seven feet six inches long. Remember that this is a water-tight shoe, so that the toes of the bar will have to be planed before sending it to the blacksmith.

While the blacksmith is making the bar to shape, we will finish the laying off template. As stated before, the side of the template which was against the bulkhead having the circled holes on it, will apply up; so that the holes which were picked up with

the square will have to be transferred to the other side of the template, or through it.

This must be done very carefully. If it isn't, "bad holes" will be the result when the bar is fitted on the ship; and being very careful to see that the red holes are marked "red," and the blue holes are marked "blue" on the other side of the template.

This brings all the markings for the rivet holes on the side that the pencil circles are on, and when applying the template to the bar, this side will be up.

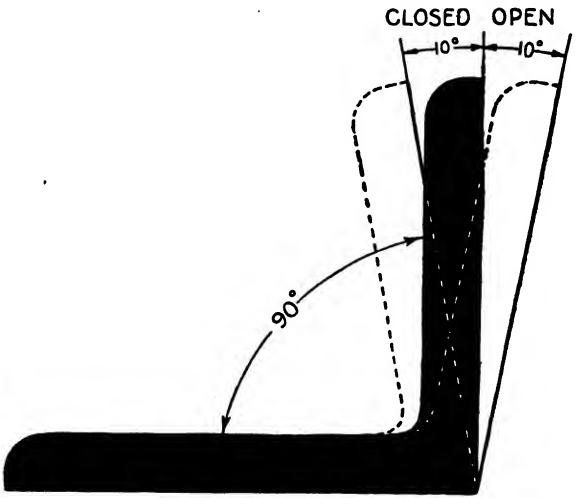


Fig. 97.—Bevel (open and closed).

The bar, when received from the blacksmith, will have to be duplicated in the same manner as in previous lessons.

Care must be observed when applying the template on the bar to have the joggles in the template fit exactly in the joggles of

the bar, and to have the heel of the template exactly even with the heel of the bar.

Bevelling.—On many parts of the ship, for instance, connections to the tank top and shell are less than 90°. As angle bars come with the flanges at 90°, one of the flanges will have to be closed, see Fig. 97.

Lifting Shell (curved) from the Hull.—In this lesson, we will take shell plate D 2, port. See Fig. 25. As indicated, this is in D strake, and plate No. 2 laps on to plate No. 1, between the frames No. 6 and No. 7, and on to plate No. 3, between the frames No. 12 and No. 13.

Note the location of the plate carefully on the drawing, as you will have to know this location in order to find it on the ship.

When the plate location is found on the hull, remove all obstructions, such as: air hose, etc., which might be in the way. Special reference is made to air hose, as it happens in many cases that this is connected to the ways, and then run through the opening for the shell plate into the ship.

Sometimes, the fitter is in such a hurry that this is overlooked, and he builds the template around the hose. Then when he comes to remove the template, he finds himself stuck. He therefore, has to cut his template to get the air hose out, or is forced to waste valuable time, in hunting the riveter, driller, chipper or caulker, to see if he can detach the hose.

After this is done, procure template wood; we will need some 4-inch and 6-inch wood.

Now find the fore end lap of D 2, which should be on the bottom of plate E 3, and on the top of plate C 2, as shown in Fig. 98, and this is shown by the lap mark.

We find on the drawing, Fig. 25, that the after end of plate D 3

is twelve inches forward of the frame line No. 12. This frame line is the heel of the shell bar. The width of the lap is nine inches. Add this to the twelve inches and that gives us the forward end of plate D 2, which is twenty-one inches forward of the heel of frame No. 12. Measure this distance forward of the heel of frame No. 12 and use three holes aft of this for the plate lap. Then see that the plates D 1, C 1, C 2, E 2, E 3 are bolted

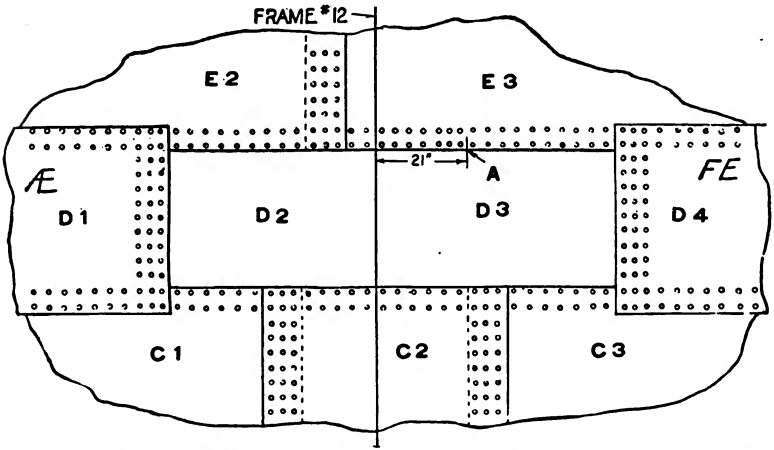


Fig. 98.—Section of shell plating on the hull; plates D2 and D3 are missing and are to be lifted.

securely, and "fair" in the longitudinals. By this is meant, that sometimes the longitudinals have dropped down out of place, or have been bent in "slinging" them into place, *don't take it for granted that the way you find the longitudinal is the proper way*. See for yourself that it is in its proper position, and if it has any kinks in it, that they are taken out.

After all this is completed, we will start to make our template.

Begin at the bottom seam of plates E2 and E3, and starting at the forward lap of plate D1, which is the lap of the after end of plate D2. Clip a piece of 6-inch template wood on this seam to the lap that was marked on the shell E3. Have enough clips on this to hold it securely. Do the same, that is, follow the above instructions at the top seam of C1 and C2.

At the forward lap of plate D1, tack two strips of the 6-inch wood onto the strips of the template wood that are clipped on the other shell plates. Two pieces are necessary to pick up the holes, as the laps are nine inches wide and our wood only six inches wide.

Then at what we will term the forward end of plate D2, and that is the lap forward of frame No. 12, tack a piece of 6-inch wood across from one seam to the other seam. Only the one piece is necessary for this, for the reason that only the lap holes that meet in each seam, the longitudinals, are picked up from the ship. The rest of the holes being spaced in afterwards. We now have the outside of our template made.

Now for the holes in frames No. 7, No. 8, No. 9, No. 10, No. 11 and No. 12 tack a strip of 4-inch template wood across the shell template at each of those frames. The 4-inch wood is wide enough because there is only a single row of rivet holes. Then, at the bulkhead frame No. 11, it will require a 6-inch strip of template wood, as this is a 5-inch by 5-inch bar with a double row of rivet holes. Then, at the transverse frame No. 12, there is also a double row of rivet holes requiring a 6-inch strip of wood.

When all the cross pieces of the template wood are tacked securely to the pieces running fore and aft of the ship, run a piece of 4-inch template wood over the holes of each longitudinal,

extending these pieces of the template wood as far as the 6-inch pieces or ends.

The template is now ready for the holes to be marked on it. This will have to be done on the ship, with a pencil, for each and every rivet hole required for the plate. Run the pencil around the circumference of each hole. After this is done, the template is ready to be removed from the ship. But before taking the clips off the template, mark the after end *A E*, and the

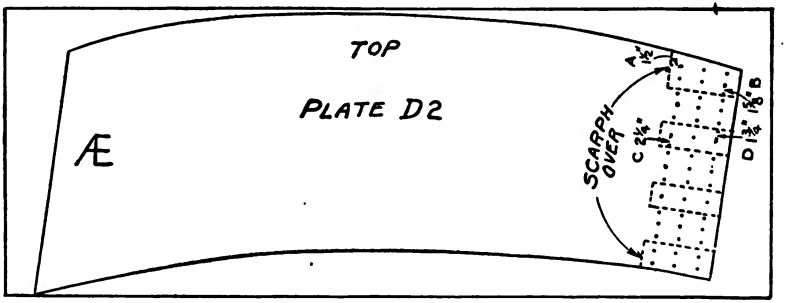


Fig. 99.—Shell template on plate (curved) showing scarphs.

top, *top*; also what plate number it is, and whether port or starboard. After this is done, the clips can be taken off and the template removed from the ship. The port plate has now been lifted.

The starboard plate can be lifted with the same template; the side of the template which was on the outside of the plate on the port side is now on the inside of the starboard plate. Secure the plate that has the order mark D2, and put the template on it, having the side up that has the rivet holes marked on it. This was the side that was against or toward the inside of the ship, and the holes are countersunk on the outside, by

having this side up; our holes will be countersunk over. As the top and bottom of the landing edge of this template have a curve in them we cannot use either side of the plate for a landing edge.

Clip the template securely to the plate, as in Fig. 99, in the most advantageous position. With the prick punch, punch a hole exactly in the center of the pencil circles. The punch must be hit hard enough with the hammer to leave its impression in the plate. With the soapstone, mark the after end and the top of plate, and take clips off, removing the template from the plate. At the fore end, the lap holes will have to be spaced in.

Snap a line from the last three holes in the lap seam to the last three holes in the bottom seam lap. Then, space the holes between seam lap and longitudinals, according to the blue print.

In this case, it is 3-inch spacing. So, divide the space between holes on the lines that we have previously snapped on the plate, into as nearly 3 inches as is possible. Better have a little less, rather than more than 3 inches.

After you have spaced these lines in, center punch those marks; also the prick punch marks. At the fore end, the corners will have to be scarphed; also, where the longitudinals cross the lap. The scarphs in the corners of the plate allow this plate D 2, to fit into plates C 2 and C 3, thereby eliminating the use of a liner.

Measure back from the holes 1½ inches, and this is the beginning of the scarph, see A, Fig. 99. Then, the width of the seam lap is 5¼ inches, and the landing of the plates is 1⅜ inches from the center of the rivet holes. Measure 1⅝ inches, allowing ¼ inch for the clearance of plate edge, from the center of the rivet holes. This is the side of the scarph. These lines will have to be center punched in. This plate being an outside strake, these scarphs will be opposite to the countersink, or as in this case, they will scarph T S (this side).

For the longitudinal scarphs, note whether the heel of the longitudinal is up or down. In this case, the heel is down. The flange that applies to the shell is 3½ inches wide. The gauge of the holes, 2 inches.

Measure 2¼ inches, ¼ of an inch being allowed for clearance of the heel of the longitudinal. This will be one side of the scarph, see C, Fig. 99.

From the center of the holes to the toe of the longitudinal is 1½ inches, allowing ¼ inch for clearance; therefore, measure 1¾ inches from the center of the rivet holes, and this is the other side of the scarph, See D, Fig. 99. The end of the scarph is 1½ inches from the last hole of the lap, or the same as A. As the longitudinals are on the inside of the plate and the countersink on the outside, it stands to reason that the scarph will be the opposite of the countersink, or as in our case, *scarph T S* (this side.

The holes in the fore end lap of this plate *Don't C S K*, as plate D3 lap is on the outside, shear landing 1⅜ inches. The top and bottom laps are *C S K* (countersink); also the after end, *C S K;* and the longitudinal holes *C S K*.

Plane the after end of top and bottom, *1⅜-inch landings. All ⅞-inch holes*. Do this according to instructions given for duplicating plates.

As plate D2 is not a straight plate, but has a roll and twist, sets will have to be made for it. On the scrieve board, find the frame lines No. 7, No. 8, No. 9, No. 10, No. 11, No. 12, and the seam laps of strake D, at these frames. In Fig. 100, an enlarged drawing of this part of the scrieve board is shown. At the point where the frame line No. 7 crosses the shell lap, measure toward the center 12 inches; it does not necessarily

have to be 12 inches; it may be any reasonable dimension that you wish to give it.

Strike the line A B. This line does not have to be parallel to the frame line. The line A B, will be the sight edge of the shell set, frame No. 7. Then, at the point where frame No. 8 strikes the shell lap, measure 12 inches from this point toward the line A B, and from this point, strike the line C D, parallel with the line A B.

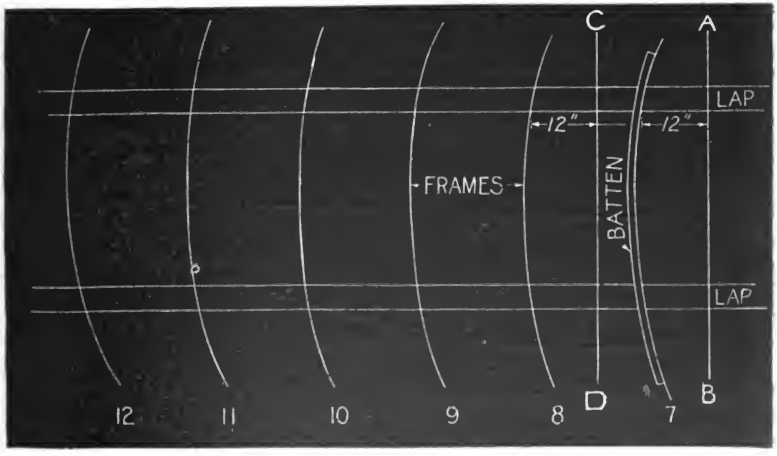


Fig. 100.—Method of obtaining template sets for curved plates from scrieve board.

That means that all points on the line C D, are equal distance from the line A B.

The line C D, is the sight edge for the shell set frame No. 8. At each point where the frames hit the shell lap, measure 12 inches and snap lines, as explained above. Care must be taken to have these lines parallel.

Make templates at each frame. On the scrieve board there would be what are known as quarter frames between the frames No. 11 and No. 12. The spacing between No. 11 and No. 12 is 10 feet, and the quarter frames would be spaced 2 feet 6 inches apart. Unless there be an extreme amount of roll and twist to the plate, it would only be necessary to make a set at the half frame line. Nail a batten to the frame line No. 7, see Fig. 100, and plane a piece of template wood to the inside edge of this batten, which is the frame line. After fitting the template

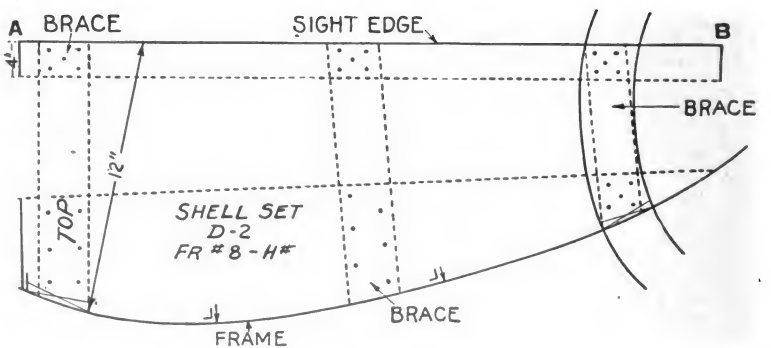


Fig. 101.—Set template for curved plate.

perfectly to the line, and this wood must extend a little beyond the top and bottom seam laps; remove the batten and nail the template wood temporarily to the scrieve board. Then have a piece of 4-inch template wood planed to a straight edge, and having the planed edge to the line A B, Fig. 101.

Now, tack the braces as shown in Fig. 101 to these two pieces of template wood, and the template is made before removing from the scrieve board; pick up the shell seam laps, and the

longitudinal heels, and mark as shown in Fig. 101. Paint the template, and it is ready for use.

Following the above instructions, make set templates at the remaining frames No. 8, No. 9, No. 10, No. 11, No. 12, and the work is completed. The shell plate being on the outside of the frames, the sets will have to apply on the inside of the plate on the opposite side to the countersinking of the holes.

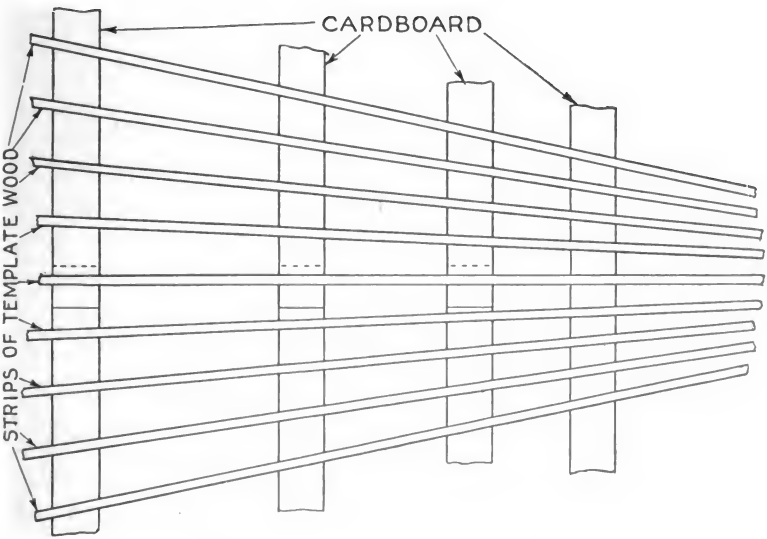


Fig. 102.—Method of building a template for the boss plate.

Lifting Boss Plate from the Hull.—First see that shell plates B 1 and C 1 are in place and bolted up tightly, that will line up the boss frame No. 5, No. 6 and No. 7, Fig. 25. Then procure some cardboard and $\frac{3}{16}$-inch template wood, at least

10 feet long. Cut the template wood in strips of about 1½ inches wide; also, cut the cardboard in strips of about 9 inches wide. Lay the strips of template wood on the loft floor in the manner shown in Fig. 102, and then tack the cardboard strips across the template wood strips.

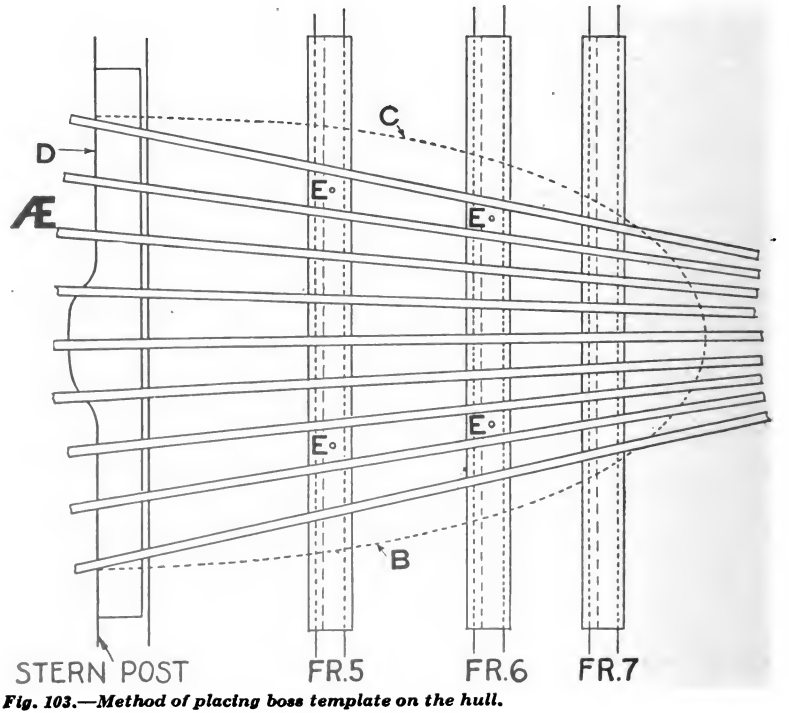


Fig. 103.—Method of placing boss template on the hull.

The reason for making the template in this shape is that the boss plate is in the shape of a cone. The fore end has a smaller radius than the after end.

After tacking the strips securely together, take the template up and clinch the tacks. Now, we are ready to place the template on the ship. With clips, hold the template in place on frames No. 5, No. 6, No. 7 and stern post, see Fig. 103. Then, mark the edge of the shell plates B 1 and C 1 on this template.

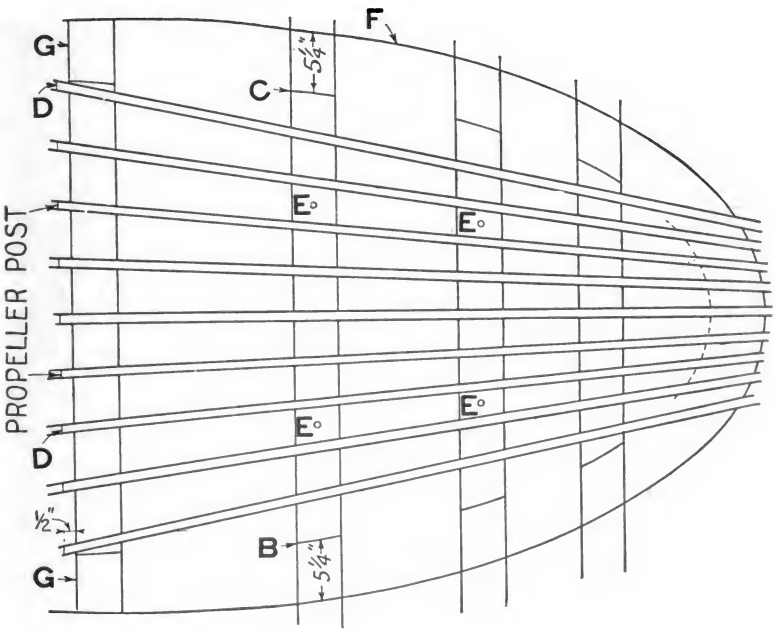


Fig. 104.—Boss template when taken from the hull.

They are shown as dotted lines B and C. Also mark the after end of the stern post frame on the template, see D, Fig. 103.

Pick up the holes E, in frames No. 5 and No. 6. These are the only holes that are put in the plate, and they are known as

tack holes, and their purpose is to hold the plate securely in place while the rest of the holes are being drilled in it.

Remove clips and take the template back to the loft floor. Fig. 104 shows the template laid down on the floor. As the tack holes are above and below the boss of the frames, that is, the part where the frames curve around the propeller shaft, they will have to be drawn in 3/16 of an inch toward the center of the plate.

The reason for this is that the plate expands, gains length when it is rolled to a radius, it being a 3/4-inch plate, and making practically a half turn, it will expand about 3/8 of an inch, that is, 3/16-inch on each side of the center of the plate.

As the lap between the boss and shell plating is 5 1/4 inches wide, measure out 5 1/4 inches from the lines B C, see Fig. 104; and applying a batten on these points, draw in the line for the edge of the boss plate F.

Measure 1/2 inch from the line of the propeller post D and draw a line G. Then, the lines F and G are the outline of the boss plate, and this plate is planed all around for caulking.

As this plate has to be sent to the rolls so that it can be rolled into shape to fit the framing (see Fig. 99), sets (or patterns) for the men at the rolls to work on have to be made.

On the after body of the scrieve board find the boss frames No. 5, No. 6 and No. 7, Fig. 105, shows the boss framing on the scrieve board. Snap a chalk line A B, about one foot from the frame No. 5. This is called the sight edge for the template. Do the same with frames No. 6 and No. 7. Have all these lines parallel. Then make a template to the shape of the frame No. 5.

Plane a piece of template wood to a straight edge and apply it on the line A B, see D, Fig. 105. Tack the cross pieces E, securely to the template wood C and D; then, the set for frame

No. 5 is ready. Make the sets for frame No. 6 and No. 7 in the same way.

After the boss plate is rolled and sent to the ship, bolt it in place, using the tack holes E.

Then space the holes in the seams; that is, to the shell plates B1 and C1; also in the part that laps on the propeller post, and

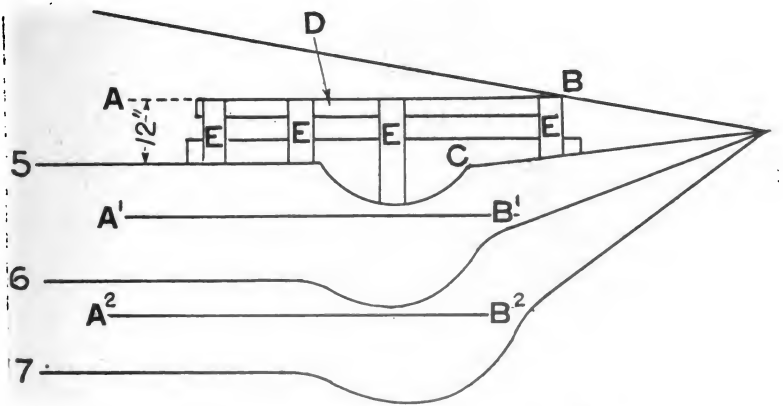


Fig. 105.—Method of obtaining the curve of boss plate from scrieve board.

have a driller drill them in. Where shell plate B1 laps over shell plate C1, a liner will have to be fitted, as shown in Fig. 106.

Lifting a Margin Bar—In lifting a margin bar, a pitching

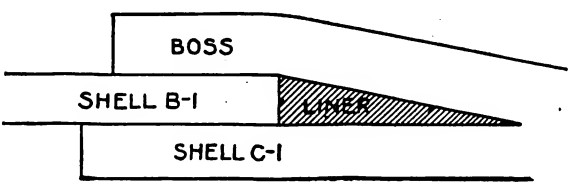


Fig. 106.—Position of liner under the boss plate.

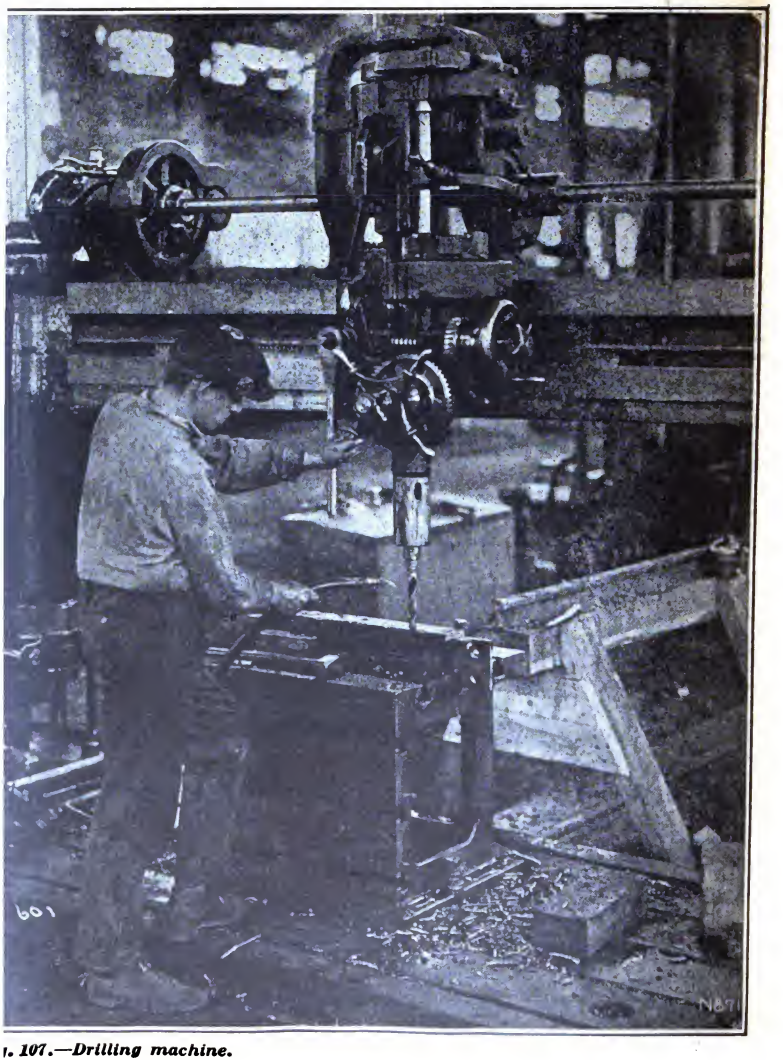


Fig. 107.—Drilling machine.

spot is used to get holes fair in each flange, the template being laid on the deck, the holes marked from underneath.

Before removing template, a spot is put on the template and side of the ship, template being lifted up the spot is transferred to the underside of template and spot on the shell being transferred to the deck. The template is placed again on side of ship and both plates held together, holes being marked from the shell of the ship and spot being held accurately will give you fair holes in both flanges.

RIVETS AND RIVETING

Table to Find Distance Between Rivet Holes.—Fig. 108 shows rivet spacing in inches. Referring to the table on page

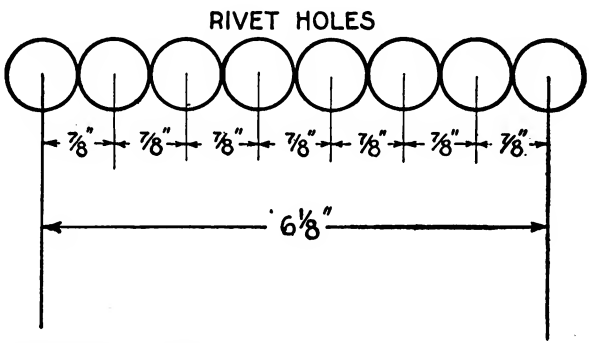


Fig. 108—Rivet spacing in inches.

165, line A is the size of the rivet; for example, ¼-inch, ⅜-inch, ½-inch, ⅝-inch to 1¼-inch.

Line A[1] is the number of diameters the rivets are spaced, from center to center. For example, 1½-inch diameter, 1⅝-inch diameter, 1¾-inch diameter, 1⅞-inch diameter to 9-inch diameter.

Suppose that we want to find the spacing of a ⅞-inch rivet, spaced seven diameters apart.

Table to Find Distance between Rivet Holes

DIAMETER OF RIVET SPACING IN INCHES

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
	NUMBER OF DIAMETERS																						
A[1]		1½	1⅝	1¾	1⅞	2½	3	3½	4	4½	5	5½	6	6½	7	7¼	7½	7¾	8	8¼	8½	8¾	9
B[1]	¼	⅜	7/16	7/16	½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1 13/16	1⅞	1 15/16	2	2 1/16	2⅛	2 1/16	2¼
C[1]	⅜	9/16	⅝	11/16	11/16	15/16	1⅛	1 5/16	1½	1 11/16	1⅞	1 1/16	2¼	2 7/16	2⅝	2¾	2 13/16	2 15/16	3	3⅛	3 1/16	3 1/16	3⅜
D[1]	½	¾	13/16	⅞	15/16	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	3⅝	3¾	3⅞	4	4⅛	4¼	4⅜	4½
E[1]	⅝	15/16	1	1⅛	1 3/16	1 9/16	1⅞	2 3/16	2½	2 13/16	3⅛	3 7/16	3¾	4 1/16	4⅜	4 9/16	4 11/16	4⅞	5	5 3/16	5 5/16	5½	5⅝
F[1]	¾	1⅛	1¼	1 5/16	1 7/16	1⅞	2¼	2⅝	3	3⅜	3¾	4⅛	4½	4⅞	5¼	5 7/16	5⅝	5 13/16	6	6 3/16	6⅜	6 9/16	6¾
G[1]	⅞	1 5/16	1 7/16	1 9/16	1⅝	2 3/16	2⅝	3 1/16	3½	3 15/16	4⅜	4 13/16	5¼	5 11/16	6⅛	6⅝	6 9/16	6 13/16	7	7¼	7 1/16	7 11/16	7⅞
H[1]	1	1½	1⅝	1¾	1⅞	2½	3	3½	4	4½	5	5½	6	6½	7	7¼	7½	7¾	8	8¼	8½	8¾	9
I[1]	1⅛	1 11/16	1 13/16	2	2⅛	2 13/16	3⅜	3 13/16	4½	5 5/16	5⅝	6 3/16	6¾	7 5/16	7⅞	8⅛	8 7/16	8¾	9	9 5/16	9 9/16	9⅞	10⅛
J[1]	1¼	1⅞	2 1/16	2 3/16	2⅜	3 1/8	3¾	4⅜	5	5⅝	6¼	6⅞	7½	8⅛	8¾	9 1/16	9⅜	9 11/16	10	10 5/16	10⅝	10 15/16	11¼

Fig. 109.—Riveting plates.

Read down the line A until we come to 7/8-inch; that is the size of rivet, and it is on the line G^1.

Reading over the line A^1, until we come to the figure 7; that is the number of diameters spaced apart.

It is on the line O.

Then, in the space where line O meets line G^1, is the spacing in inches, which is 6 1/8 inches, and that is the spacing in inches of 7/8-inch rivet spaced seven diameters; and that is obtained by multiplying the diameter of the rivet by the number of diameters spaced apart. For example, 7-inch × 7/8-inch = 6 1/8 inches.

LLOYD'S RULES FOR RIVETS

THICKNESS OF PLATES	In. .22 not over .34	In. .34 not over .48	In. .48 not over .66	In. .66 not over .88	In. .88 not over 1.14	In. 1.14 to 1.20
DIAMETER OF RIVETS	5/8	3/4	7/8	1	1 1/8	1 1/4
Breadth of quadruple riveted butt straps in inches	....	....	22	25	28 1/4	31 1/2
Breadth of triple riveted butt straps	....	14 1/4	16 3/4	19	21 1/2	24
Breadth of double riveted butt straps	8	9 3/4	11 1/4	....	....	....
Breadth of single riveted butt straps	4 1/2	5 1/4	....	....	....	....
Breadth of quadruple butt laps in inches	....	....	12	14	16	18
Breadth of triple riveted butt laps in inches	....	7 1/2	9	10 1/2	12	13 1/2
Breadth of double riveted butt laps in inches	4 1/2	5	6	....	....	....
Breadth of single riveted butt laps in inches	2 1/2	3	....	....	....	....
Breadth of triple riveted edge laps in inches	....	....	....	8 1/2	9 1/2	10 1/2
Breadth of double riveted edge laps in inches	3 3/4	4 1/2	5 1/4	6	6 3/4	7 1/2
Breadth of double riveted edge laps in inches	2 1/4	2 1/2	3	....	....	....

Fig. 110.—Picking up lines from mold loft floor. Place a series of tacks with the heads resting on the required line. The heads of the tacks should be driven into the floor slightly, to prevent them moving out of place. Place a piece of stick wide enough to cover the member, with the grain of the wood running in the direction that will show the least amount of end wood (to prevent splitting when cut to shape). Give it several light taps with the hammer in the direction of the curve. The heads of the tacks will leave marks into which brads can be driven and around which a batten can be bent and the curve marked.

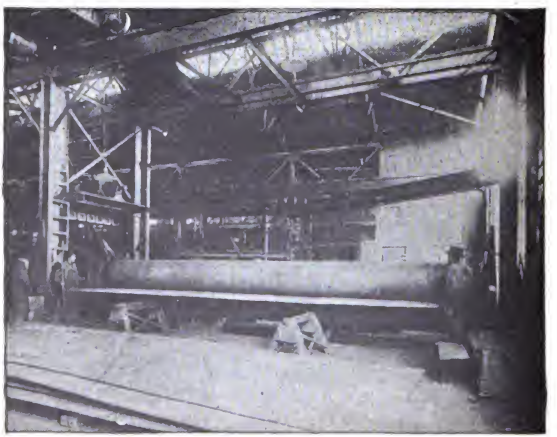


Fig. 111.—Machine for rolling plates to shape of ship.

LLOYD'S RULES FOR RIVETS—*Continued*

MAXIMUM SPACING FROM CENTER TO CENTER

THICKNESS OF PLATES		In. .22 not over 34	In. .34 not over .48	In. .48 not over .48	In. .66 not over .88	In. .88 not over 1.14	In. 1.14 to 1.20
DIAMETER OF RIVETS		5/8	3/4	7/8	1	1 1/8	1 1/4
3 1/2 Dia. C to C	Butts of outside plating and all beam stringer plates, except quadruple riveted butt laps	2 1/4	2 5/8	3 1/8	3 1/2	4	4 3/8
4 Dia. C to C	In edges of outside plating (forward and aft) quadruple riveted butt laps and double butt straps, butts of deck plating, butts of margin plates, girders, tie plates and floor plates, also butts and edges of inner bottom plating	2 1/2	3	3 1/2	4	4 1/2	5
4 1/2 Dia. C to C	In gunwale, angle bars, margin plate angles, quintuple riveted, butt laps, edges and butts of bulkhead plating, angles connecting side stringers to web frames, and edges of deep plating, W. T. bulkhead frames except shell flange	2 3/4	3 3/8	4	4 1/2	....	....
5 Dia. C to C	In flat keel angles vertical angles connecting floors and center girder shell flange of W. T. bulkhead frames, butts and edges of mast plates, floor and cross ties in after peak	3 1/8	3 3/4	4 3/8	5	5 5/8	6 1/4
6 Dia. C to C	In deck plating to beams when single flange beams are fitted at alternate frames	3 3/4	4 1/2	5 1/4	....	....	....
7 Dia. C to C	In frames, reversed frames, floors, keelsons, beam angles, deck and hold stringer angles, face angles on web frames and side stringers, bulkhead stiffeners, longitudinal angles on continuous girders, vertical angles, connecting floors and side girders, and deck plating to beams, except where single flange beams are fitted at alternate frames	4 1/2	5 1/4	6 1/4	7	....	....

The following table is a sample of riveting schedule given on blue print:

DECK PLAN

CONNECTIONS	RIVETS SIZE	DIA. SPACING	RIVETS ROWS
DK PLATING TO TRANS. ANGLE CLIPS	⅞.	5"	SINGLE
DK PLATING TO LONG.	⅞	6"	"
DK PLATING TO BH BOUNDING BAR	⅞	5"	"
2 ¾ BUTT LAPS	⅞	5"	"
5 ¼ BUTT LAPS	⅞	4½"	DOUBLE
GUNWALE ANGLE BAR	⅞	5"	SINGLE
E & B CASING ANGLE TO DK	⅞	5"	"
CARGO HATCH ANGLE TO DK	⅞	5"	"
MIS HATCH BOUND. BARS	⅞	5"	"

Fig. 112.—Training gang in chipping and caulking by the Emergency Fleet Corporation.—Courtesy of the General Electric Co.

PICTORIAL SUPPLEMENT

(Courtesy of Great Lakes Engineering Works)

SHOP OPERATIONS

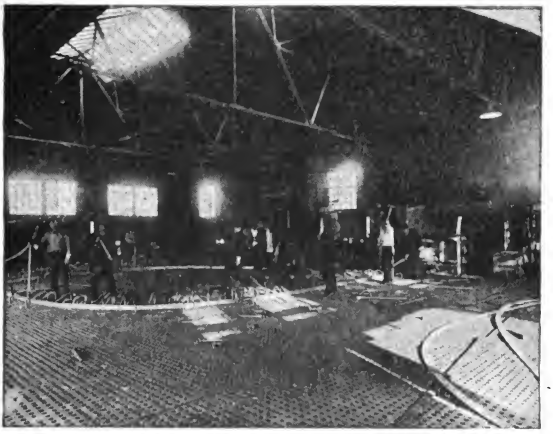


Fig. 113.—Slab furnace where angles and channels are heated and bent to shape.

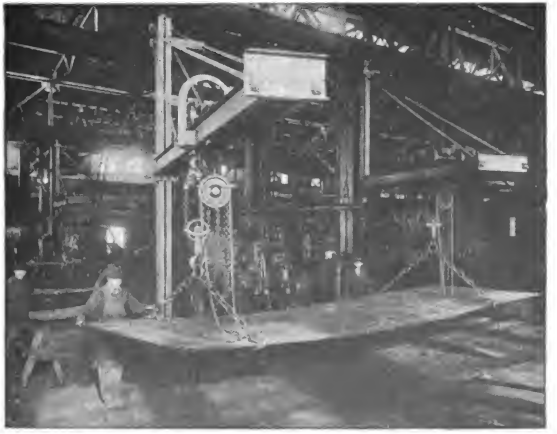


Fig. 114.—Shows plate being punched ready for riveting. The plate and angle shops are 300 feet long and are served with quick travel overhead cranes.

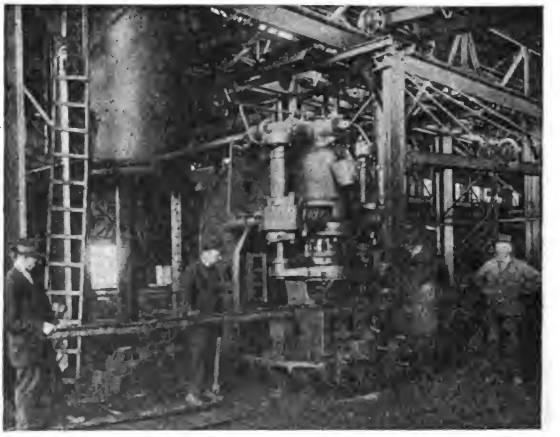


Fig. 115.—Joggler where channel and angle irons are shaped.

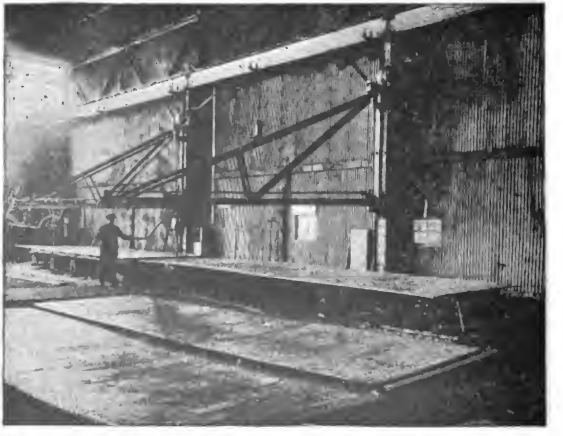


Fig. 116.—Plate being punched ready for riveting. The plate and angle shops are 300 feet long and are served with quick-travel overhead cranes.

BUILDING A BULK FREIGHTER

Fig. 117.—Keel blocks for 10,000-ton steamer.

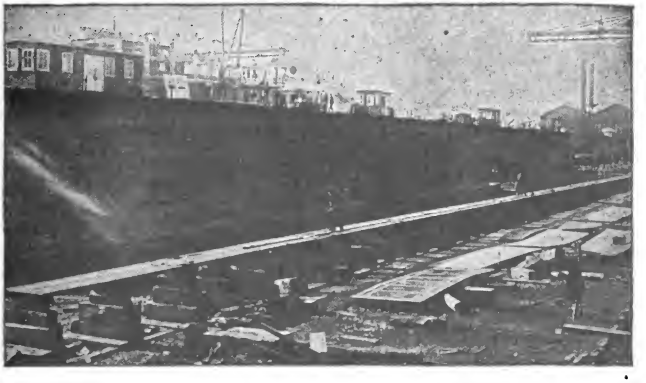


Fig. 118.—Keel one day later, showing lower plates in position.

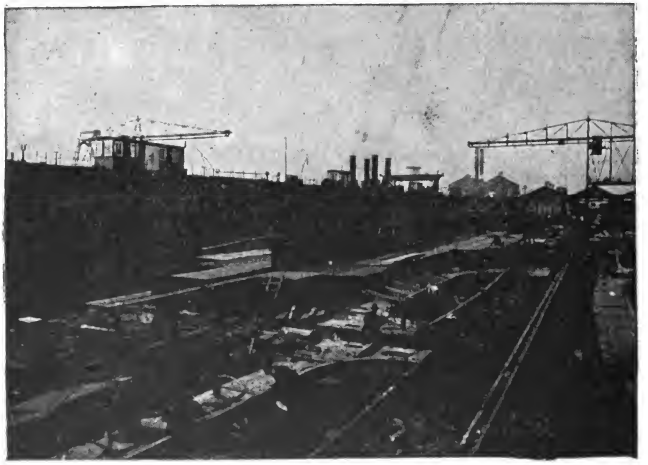


Fig. 119.—Keel three days later.

Fig. 120.—Construction at the end of twenty-four days.

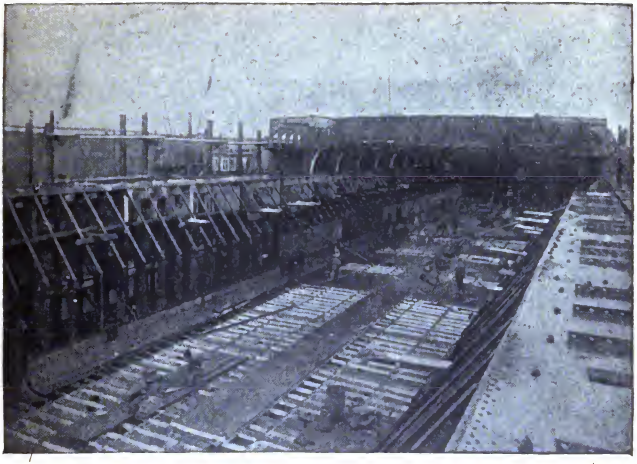


Fig. 121.—Work as completed at end of thirty-six days.

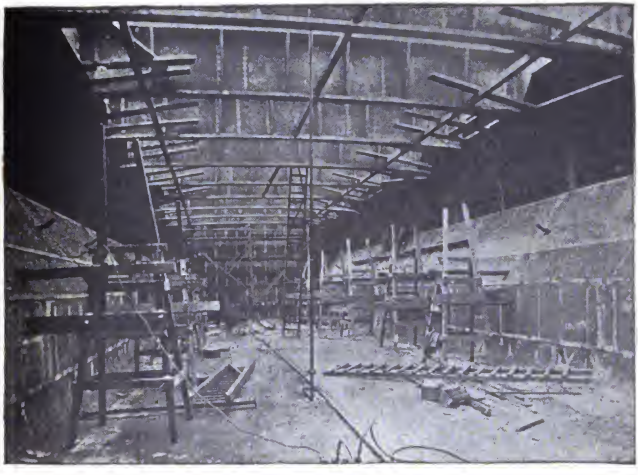


Fig. 122.—Appearance of hold at end of forty-five days.

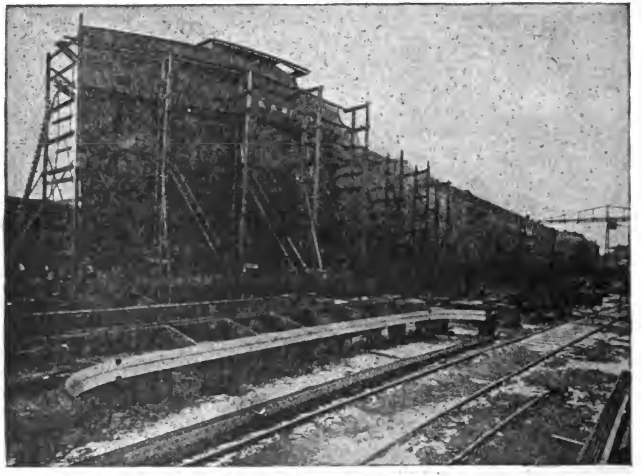


Fig. 123.—Vessel nearing completion, fifty-seven days from time of laying keel.

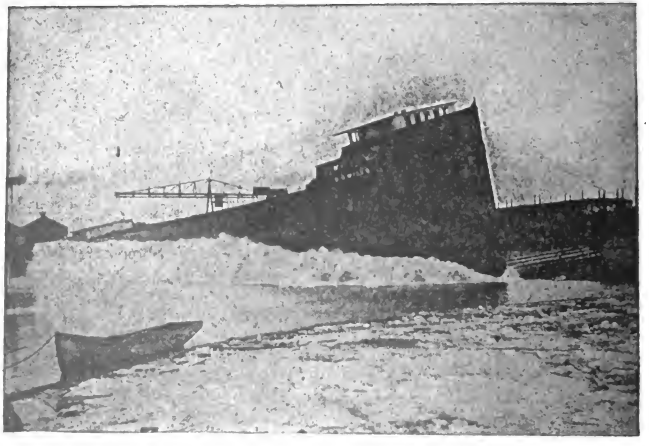


Fig. 124.—Launch of the 10,000-tonner eighty days after keel was laid.

LAUNCHING A BULK FREIGHTER

As the hull approaches completion, preparations are made for the launching. It should be understood that these flat bottomed,

Fig. 125.—View of stern, showing the launching ways and the three triggers which retain the vessel at this end.

cargo-carrying vessels are, in the Great Lakes district, launched sideways into the water. This can be done in a narrow slip, without obstructing navigation in the channel. No cradle is required for supporting the sliding hull, as is necessary with sharper built, high-speed vessels.

Before the time set for launching, the sloping beams know as the "ways," and shown in all the illustrations, are solidly lai beneath the vessel, with their smooth upper surfaces lined up i the same plane with one another. New piles of blocking (show in Figs. 125 to 127) are then erected on the ways, with top block supported by wooden wedges whose ends are barely entered, a shown best at A, in Fig. 126. Before laying this blocking, th

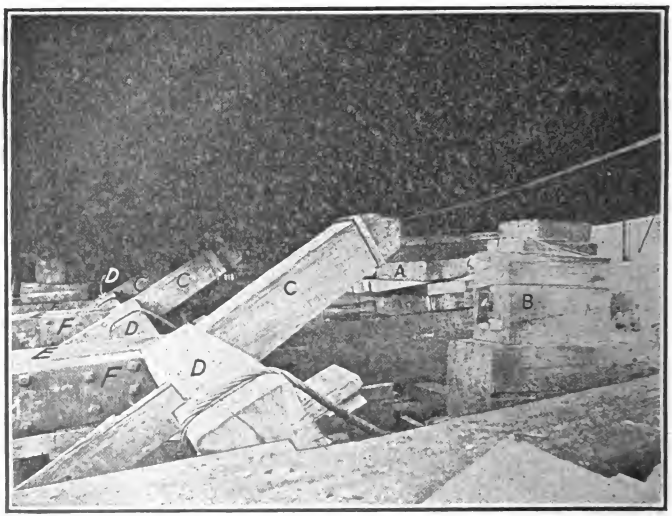


Fig. 126.—Details of the trigger, and the stationary and sliding blocking under the bow.

surface of the way beneath the pile is greased, and a dog is driven in to prevent the blocking slipping, until the hour arrives for the launching.

When everything is ready, all the wedges A, in all the piles are driven in, and the whole ship is thus lifted onto the ways. The stationary piles, such as B, in Fig. 126, are then loosened and knocked out of the way. To facilitate this, it will be noticed

that in pile B, is a double wedge block, held together by a steel plate with cross pins at each end.

If the hull be not entirely lifted from the blocking, the removal of the pin in the plate permits the upper wedge block to slide off the lower one as soon as the vessel begins to move.

Fig. 127.—The man that wields the axe that cuts the rope that binds the trigger that holds the ship.

Provision has to be made to keep the vessel from sliding off into the water after it has been raised onto the ways by the driving of the wedges, and before the moment for launching arrives.

To effect this, struts or "dog shores" C, (as shown in Figs. 125 to 127) are set against the seam of the keel-plate of the

vessel, with their lower ends bearing on triggers D, which, in turn are supported at the inner ends against abutments F, on the sides of the ways E. The dog shore and the abutment are so located as to make each trigger a lever of high ratio, and the

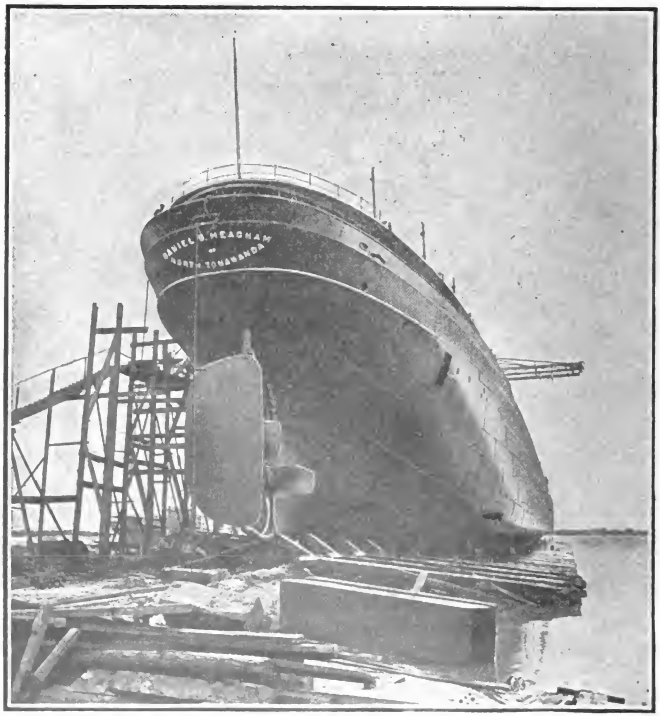


Fig. 128.—General view of the vessel on the launching ways.

force with which the vessel tends to slide down the ways is transferred (in diminished degree) to the ropes looped around the outer end of each. As may be seen in Fig. 127, these ropes are carried to the upper side of the berth, where they are attached to

posts in the ground by manila ropes and tackle blocks, by which the triggers and dog shores are strained up against the keel plate. It is the chopping of these ropes, where they are looped around the posts, that finally releases the vessel.

In this case there were eight triggers—three each at the bow and stern, and two amidships. In Fig. 127, a workman is shown

Fig. 129.—Cargo hold of modern bulk freight steamer of Great Lakes.

in pantomime in the act of cutting one of the trigger ropes. If he had done it in reality at the time the picture was taken, it is well within the bounds of possibility that he might have been "fired."

The order of procedure in launching is something like this: First, the exposed portion of the upper side of the ways is greased, the area under the blocking having been already treated as

explained. Then a small army of men is set at work driving the wedges (see A, in Fig. 126), which raise the vessel onto the ways. After a few minutes of driving a period of rest follows, to allow the blocking to settle as it receives the weight. Then a second period of driving, another of rest, and the final drive, which leaves most or all of the ground blocking free, the vessel being now held from sliding only by the triggers and the dogs driven into the ways.

As the blocking and the dogs are removed from each section, the foreman of that section, assured by careful inspection that everything is free, removes from the ground a white stake previously set outside of his section. In addition there are three stakes at each end of the line, representing the three piles of keel blocking at the stem and the stern.

As the clearing away of each section proceeds, the superintendent is informed of the progress of the work by the successive removal of the stakes, and the final removal of the keel block stakes at the ends. When all is thus known to be ready, the time for launching has arrived, and the workmen come out from under.

Now the speeches are made, and the girl with the champagne bottle takes her place on the stand at the prow. Then the superintendent gives the order and the two amidship trigger ropes are cut. The ship is flexible enough to spring down the ways several inches when this is done being still held at the stem and stern.

A fixed gauge is generally set in the ground amidships, just touching the side of the vessel before the triggers are released. The deflection is measured by the resulting gap, to get some idea of the rigidity of the structure. Finally the order is given to cut the stem and stern trigger ropes, and the vessel is thereby released.

This whole mechanism, it will be seen, is of the simplest. In its essentials, it has been changed little in generations, though it has been modified somewhat for the sidewise launching. The carefulness of the axmen in cutting the trigger ropes at the moment of the signal, is relied on to release both ends simultaneously.

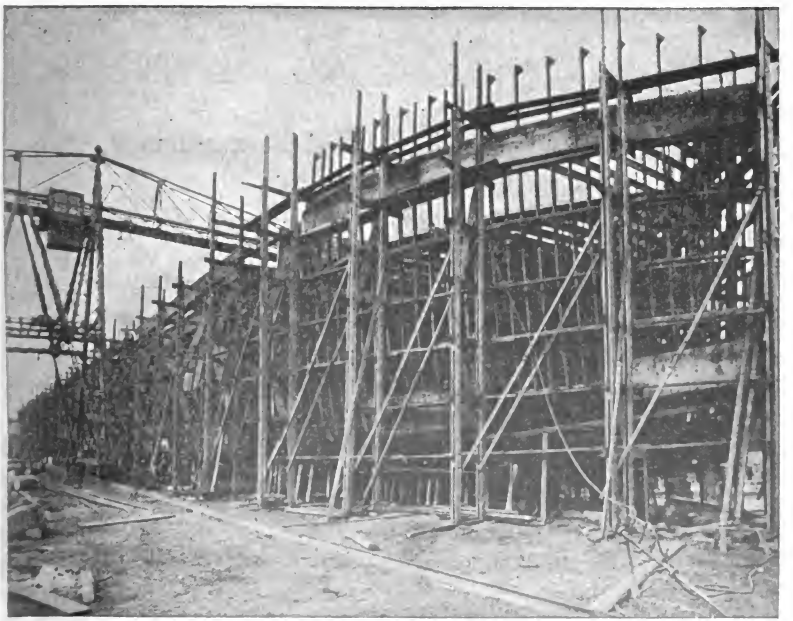


Fig. 130.—Shows vessel in frame.